



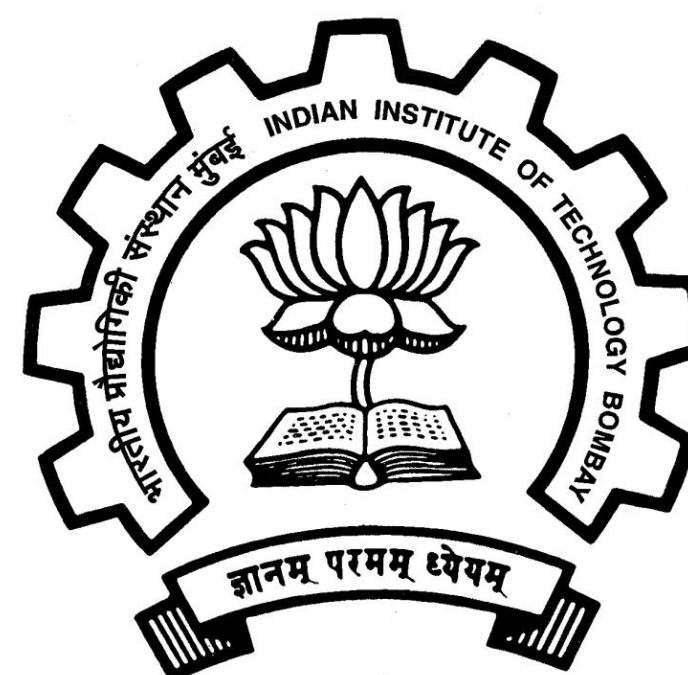
OCLEAR - An Indoor Air Purifier

Submitted in partial fulfillment of the requirement of the degree of

Master of Design
by

Sukhadev Mohanlal Kumavat
22m2237

Project Guide
Prof. Avinash Shende



IDC School of Design

Approval Form

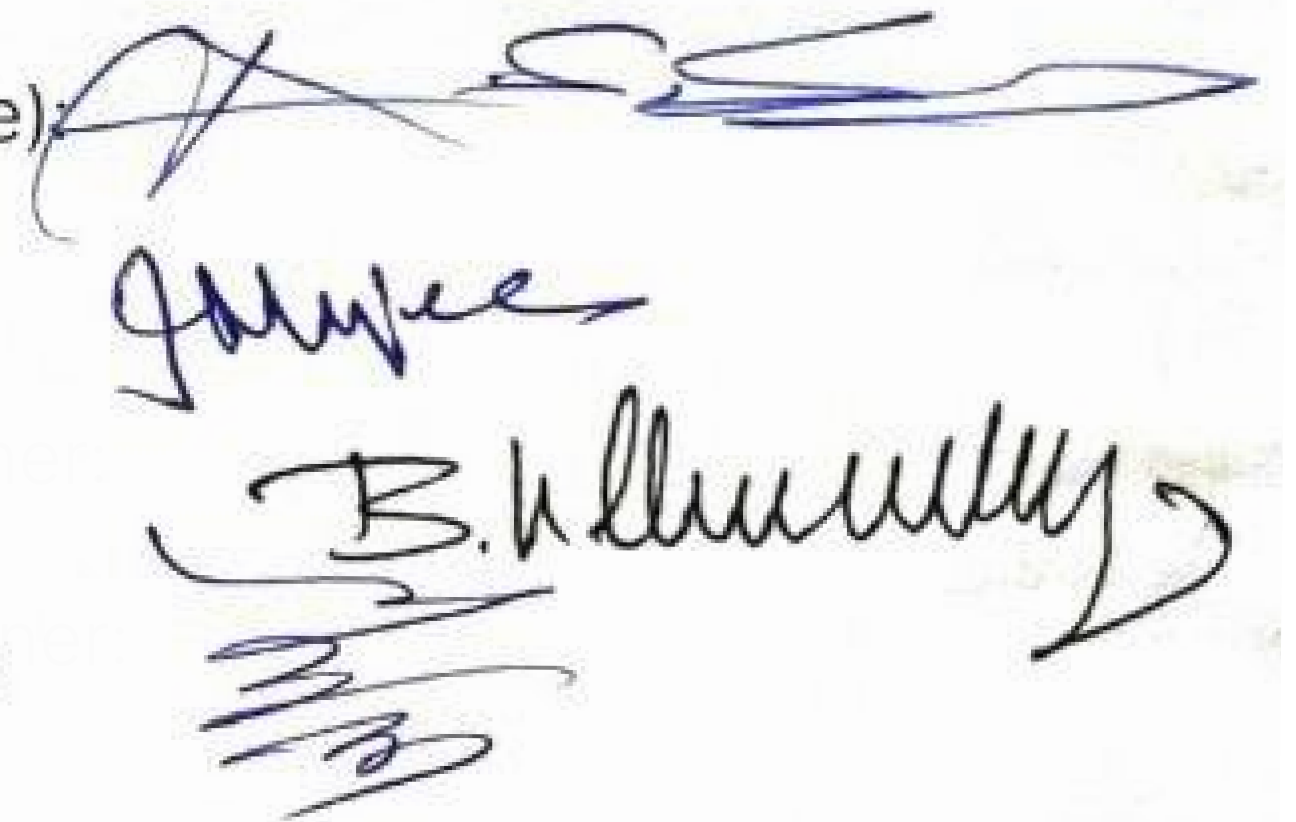
This is to certify that the Industrial Design Project entitled "Oclear - An Indoor Air Purifier" by Sukhadev Kumavat is approved for partial fulfillment for the Master of Design degree in Industrial Design.

Prof. Avinash Shende (Project Guide):

Signature of the Chair Person:

Signature of the Internal Examiner:

Signature of the External Examiner:

The image shows three handwritten signatures in blue ink. The first signature is for Prof. Avinash Shende, the second is for the Chair Person, and the third is for the Internal Examiner. The signatures are written in a cursive style.

Dare: 25-11-2023

Place: IDC School of Design, IIT Bombay

Declaration Form

I, declare that this written report represents my ideas in my own words, and where others' ideas or words have been included I have adequately cited and referenced the original sources.

I also declare that I have adhered to all principles of academic honesty and integrity and have not falsified, misinterpreted or fabricated any idea, data, facts or source in my submission.

I understand that any violation of the above will be caused for disciplinary action by the Institute and can also evoke penal action from the source, from which proper permission has not been taken or improperly been cited.

Signature:



Name of the student: Sukhadev Mohanlal Kumavat

Roll No.: 22m2237

Date: 15-11-2023

Abstract

This is a College course project in an effort to understand the Design Process that is followed to design any product for general consumers.

The topic selected for the project was the Indoor air purifier. The Concise brief can be Quoted as "To design an air purifier which enhances the experience of the user such that they tend to use an air purifier more often. The product should be so intuitive that people tend to ask more about the product thereby spreading awareness. Also keeping in mind usability, serviceability, ergonomics, aesthetics, visual semantics as features." The issues targeted were selected based on research study that were conducted during the project.

Around the globe air quality is deteriorating day by day and an air purifier can be an effective solution to this. There are many air purifier in market but some people are still not aware about it. The goal is to show how effective an air purifier can become for their healthy lifestyle.

Acknowledgement

I would like to use this opportunity to give thanks to those who helped me going through this Course project. I would like to extend my respect to all the people who helped me in accomplishing this task.

First, I would like to thank my Course Guide, Prof. Avinash Shende, for being extremely helpful and trusting me. His expert advise and helpful comments on my work has helped me to drive my work in a proper direction and reach my goal.

I also extend my gratitude towards all my batch-mates, juniors, who have always supported me and inspired me throughout this Project. I also want to offer my appreciation towards IIT Bombay for all the help and facilities they have provided.

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Introduction

Air pollution is a significant and pressing environmental issue in India. The country faces a multitude of challenges related to air quality, stemming from a combination of factors such as rapid industrialization, urbanization, vehicular emissions, agricultural practices, and climate-related conditions. India's air pollution problem is especially pronounced in major metropolitan areas and industrial regions, including cities like Delhi, Mumbai, and Kolkata. The consequences of this air pollution crisis are far-reaching, affecting both outdoor and indoor environments, as well as public health and the broader ecosystem.

While outdoor air pollution is a well-documented concern, indoor air pollution is equally important and often overlooked. The effects of indoor air pollution are significant and pose numerous health risks, especially in a country like India where many households rely on traditional cooking methods and heating sources.

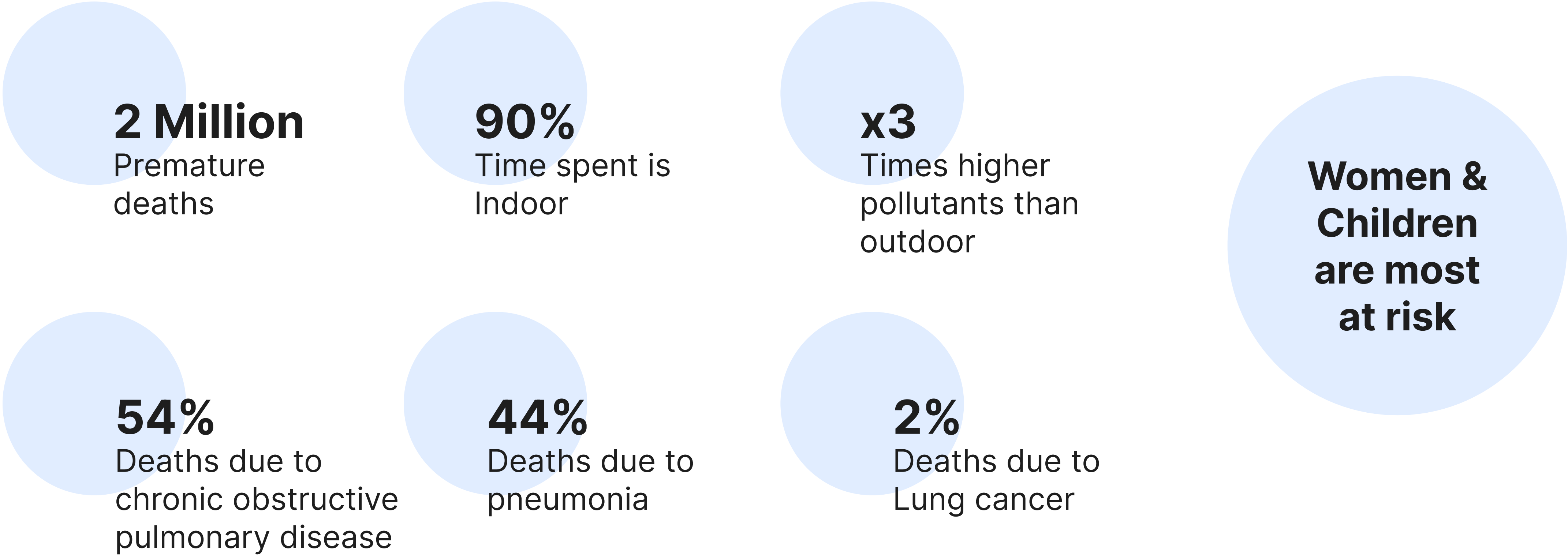
Indoor air pollution is the degradation of indoor air quality by harmful chemicals and other materials; it can be up to 10 times worse than outdoor air pollution. This is because contained areas enable potential pollutants to build up more than open spaces.

Statistics suggest that in developing countries, health impacts of indoor air pollution far outweigh those of outdoor air pollution. Indoor air pollution from solid fuels accounted for 3.5 million deaths and 4.5% global daily-adjusted life year (DALY) in 2010; it also accounted for 16% particulate matter pollution. Though there is a decrease in household air pollution from solid fuels in southeast Asia, still it ranked third among risk factors in the report of the Global Burden of Disease.⁽¹⁾ This paper provides an evidence-based insight into indoor air pollution, its effect on health, and suggested control measures.

In India, out of 0.2 billion people using fuel for cooking; 49% use firewood; 8.9% cow dung cake; 1.5% coal, lignite, or charcoal; 2.9% kerosene; 28.6% liquefied petroleum gas (LPG); 0.1% electricity; 0.4% biogas; and 0.5% any other means.⁽³⁾

The ill-effects of indoor air pollution result in about 2 million premature deaths per year, wherein 44% are due to pneumonia, 54% from chronic obstructive pulmonary disease (COPD), and 2% from lung cancer.

Due to rising air pollution, many air borne diseases are affecting our health. As people spend most of the time indoors, the air needs to be purified so as to maintain our health.



About Air purifier

Air purifiers are devices designed to improve indoor air quality by removing pollutants, allergens, and other contaminants from the air. Here are some reasons why you might need an air purifier for your home:

1. Removal of airborne particles: Air purifiers can effectively capture and remove airborne particles such as dust, pollen, pet dander, mold spores, and other allergens. This is particularly beneficial for individuals with allergies or respiratory conditions like asthma.
2. Elimination of indoor odors: Air purifiers can help eliminate unpleasant odors caused by cooking, pets, tobacco smoke, and other sources. They work by filtering out the odor-causing particles and pollutants.
3. Removal of harmful gases: Some air purifiers are equipped with activated carbon filters that can absorb and remove harmful gases and volatile organic compounds (VOCs) from the air, which are released by household products, paints, cleaning agents, and more.
4. Reduction of airborne germs and viruses: Certain air purifiers are designed to capture and destroy bacteria, viruses, and other pathogens, helping to reduce the spread of illnesses within the household.
5. Smoke and wildfire protection: During periods of wildfires or if you live in areas with high levels of air pollution, an air purifier can be beneficial in reducing the amount of smoke and pollutants indoors, providing a safer breathing environment.



About Air purifier



7. Protection from outdoor pollutants: Even if you live in a relatively clean environment, outdoor pollutants can still find their way indoors. Air purifiers act as a safeguard by removing these pollutants before they can cause health issues.
8. Improved sleep and overall health: Breathing clean air can lead to better sleep quality and overall well-being. Reduced exposure to airborne irritants can help prevent or alleviate respiratory problems and improve overall health.
9. Beneficial for pets: Air purifiers can help reduce pet dander and odors, making it easier for people with allergies to coexist with their furry companions.
10. Dust and pet hair reduction: If you have shedding pets or frequent dust accumulation, an air purifier can help minimize the amount of dust and pet hair in your home, making it easier to maintain a clean living environment.
11. Preventive maintenance: Air purifiers can help protect your HVAC system by reducing the buildup of dust and debris, potentially extending the lifespan of your equipment.

It's important to note that not all air purifiers are the same, and their effectiveness can vary depending on the type of filter they use, room size, and the specific pollutants you want to address. When selecting an air purifier, it's essential to consider your specific needs and choose a model that is appropriate for your home's size and the types of contaminants you wish to remove.

Technology used

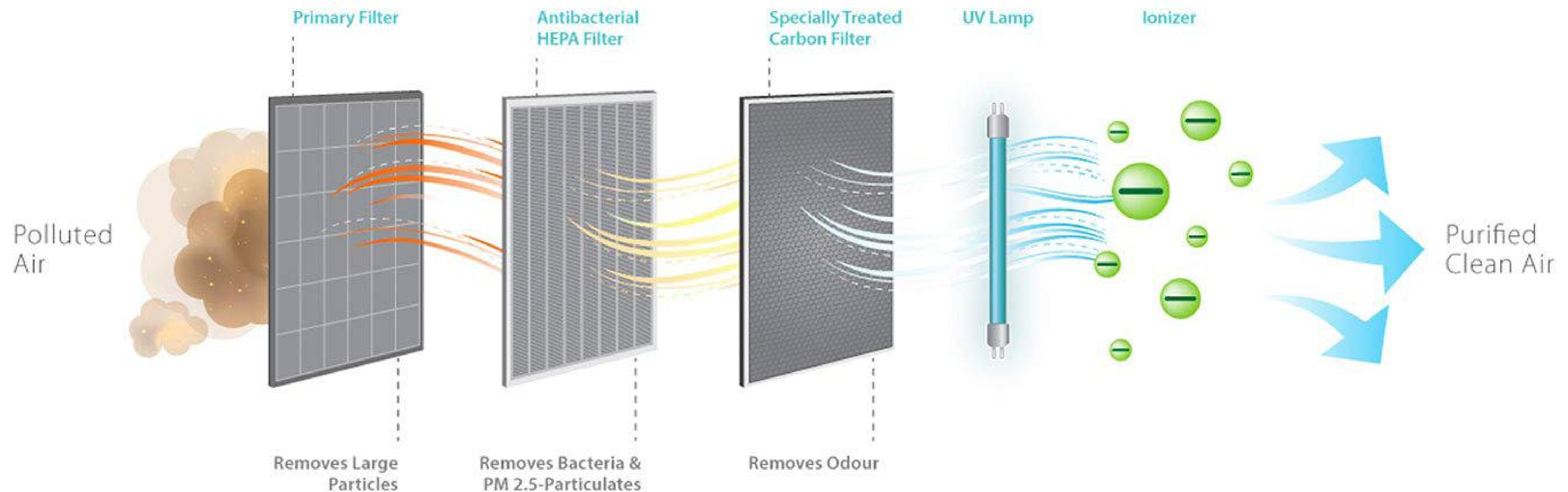
There are several methods and technologies used to purify air and improve indoor air quality. Here are some of the most common ones:

1. High-Efficiency Particulate Air (HEPA) Filters: HEPA filters are very effective at capturing airborne particles, including dust, pollen, pet dander, mold spores, and other allergens. They can remove particles as small as 0.3 microns with a high efficiency rate, typically around 99.97%.
2. Activated Carbon Filters: Activated carbon filters are useful for adsorbing and removing odors, harmful gases, and VOCs from the air. They work by trapping these substances on the surface of the carbon filter.
3. Ionic Air Purifiers/Ionizers: Ionic air purifiers release negatively charged ions into the air, which attach to airborne particles, causing them to become heavier and eventually fall to the ground. Some models also have an electrostatic plate that collects these particles.
4. Ultraviolet Germicidal Irradiation (UVGI): UVGI systems use ultraviolet (UV) light to kill or inactivate bacteria, viruses, and other pathogens. They are often used in conjunction with other air purifying technologies to enhance their effectiveness.
5. Ozone Generators: Ozone generators produce ozone, a highly reactive gas that can help eliminate odors and kill certain airborne pollutants. However, ozone can be harmful to humans and pets when present in high concentrations, so these devices should be used with caution and only in unoccupied spaces.
6. Photocatalytic Oxidation (PCO): PCO technology uses UV light in combination with a photocatalyst (usually titanium dioxide) to convert harmful gases, VOCs, and some microorganisms into less harmful substances.
7. Electronic Air Cleaners/Electrostatic Precipitators: These devices use an electric charge to attract and trap particles as they pass through the system. The particles are then collected on metal plates and can be washed away.
8. Mechanical Filtration: Apart from HEPA filters, there are various other types of mechanical filters, such as pre-filters and washable filters, which help remove larger particles from the air.
9. Natural Ventilation: Opening windows and doors to allow fresh outdoor air to circulate through the home can help improve indoor air quality, especially when outdoor air pollution levels are low.
10. Plants: Some houseplants have air-purifying properties and can help remove certain pollutants from the air. Examples include the snake plant, spider plant, peace lily, and others.

How Air purifiers work?

They use fans to draw air in through one or more filters, trap various contaminants, and then re-circulate the cleaner air back into the room. Combining multiple air purification methods can often yield the best results. When choosing an air purifier, it's essential to consider the specific pollutants

you want to address and the size of the space you need to purify. Additionally, regular maintenance and filter replacement are crucial to ensure the air purifier continues to work effectively.



Existing brands

1. Dyson: Dyson is a renowned brand that offers a range of technologically advanced air purifiers with HEPA filters and additional features like bladeless fans.
2. Honeywell: Honeywell manufactures air purifiers for residential and commercial use, providing various filtration technologies like HEPA filters and activated carbon filters.
3. Blueair: Blueair specializes in high-performance air purifiers with advanced filtration systems designed to remove pollutants and allergens.
4. Winix: Winix offers a range of air purifiers with HEPA filters, activated carbon filters, and smart features like air quality sensors.
5. Coway: Coway is a well-known brand for air purifiers and other home appliances, offering products with multiple filtration stages.
6. Philips: Philips produces air purifiers with HEPA filters and other advanced filtration technologies for improved indoor air quality.
7. Levoit: Levoit manufactures air purifiers designed to be efficient, quiet, and suitable for different room sizes.
8. Rabbit Air: Rabbit Air focuses on producing high-quality air purifiers with customizable filters and stylish designs.
9. Sharp: Sharp offers air purifiers with HEPA filters and Plasmacluster Ion technology for comprehensive air purification.
10. Alen: Alen specializes in air purifiers with customizable filter options, catering to specific air quality needs.
11. Molekule: Molekule is known for its air purifiers that utilize PECO (Photo Electrochemical Oxidation) technology for pollutant removal.
12. Airmega: Airmega produces air purifiers with dual HEPA filters and smart features to monitor and control indoor air quality.
13. GermGuardian: GermGuardian manufactures air purifiers with HEPA filters and UV-C light technology to eliminate germs and viruses.
14. Airoid: Airoid focuses on air purifiers designed to eliminate airborne pathogens using NASA-developed technology.
15. Xiaomi: Xiaomi is a well-known brand that offers smart air purifiers with various filtration technologies and smart features.
16. Whirlpool: Whirlpool manufactures air purifiers with HEPA filters and additional features like odor and VOC reduction.
17. Airfree: Airfree specializes in filterless air purifiers that use patented technology to destroy airborne allergens and microorganisms.
18. Fellowes: Fellowes produces air purifiers with true HEPA filters and additional air quality monitoring features.
19. Samsung: Samsung offers air purifiers with various filtration systems designed to enhance indoor air quality.
20. TruSens: TruSens produces air purifiers with dual airflow and HEPA filtration for improved air circulation.

Competitive Benchmarking



DYSON
bladeless fans.



HONEYWELL
Commercial use



BLUEAIR
Advanced filter



WINIX
Air Quality
Sensors



COWAY
Multiple Filtration stages



PHILIPS
Indoor Air quality



LEVOIT
Quite



RABBIT AIR
Customisable filters



SHARP
Plasma Cluster Ion
Technology



ALEN
Customisable
filters



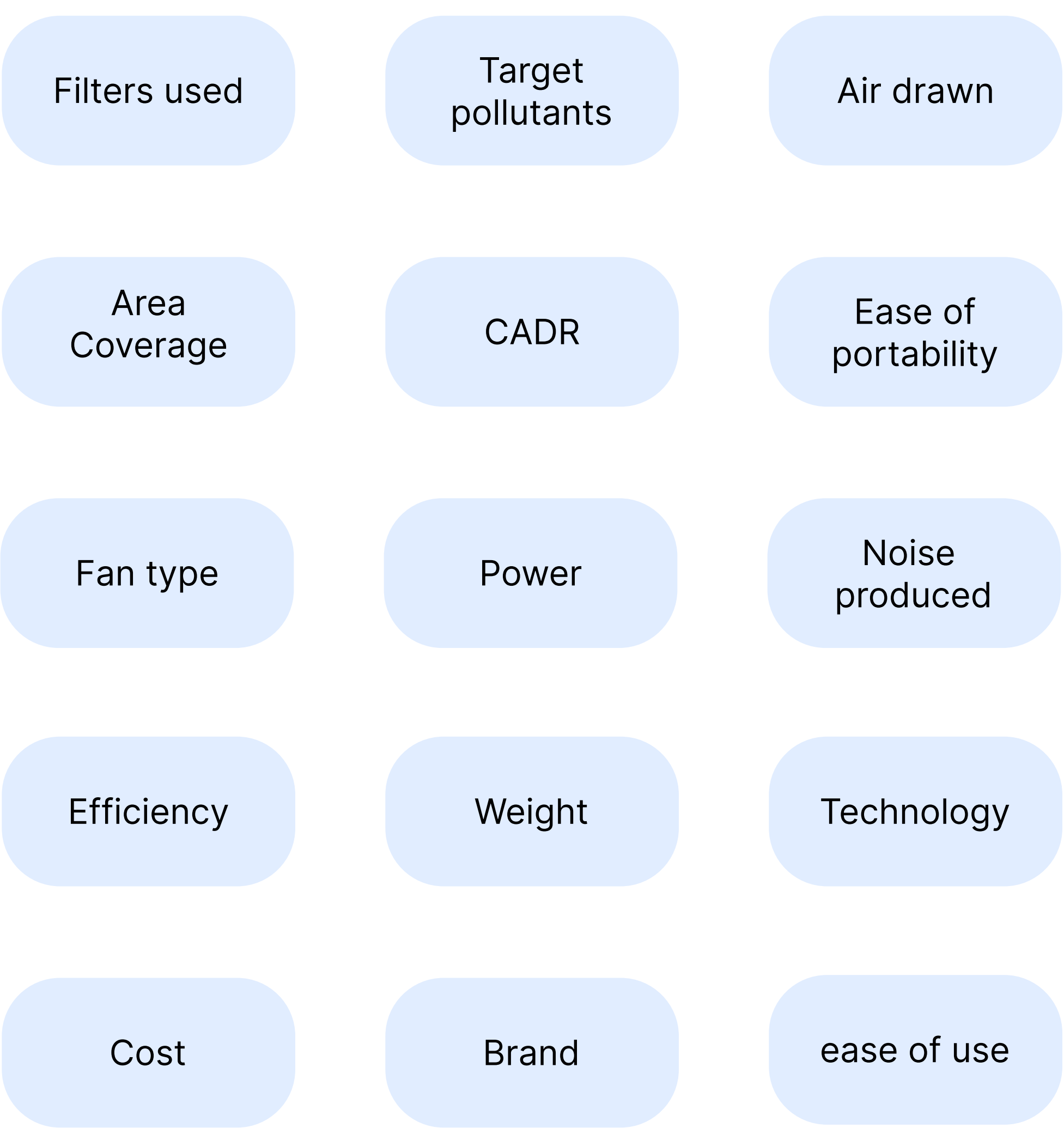
MOLEKULE
PECO Technology



GERM GUARDIAN
UV-C Light technology

How air purifiers differ

Air purifiers vary according to:



Indoor air purifiers, also known as air cleaners, come in various types and have different features, technologies, and capabilities. They differ from each other in several ways:

- 1. Filtration Technology
- 2. Coverage Area
- 3. Clean Air Delivery Rate (CADR)
- 4. Noise Level
- 5. Portability and Design
- 6. Additional Features
- 7. Maintenance
- 8. Price
- 9. Effectiveness for Specific Allergens or Pollutants
- 10. Other factors

When choosing an air purifier, it's important to consider your specific needs and priorities in terms of air quality improvement. Read product specifications and reviews to determine which air purifier is the best fit for your situation.

Other research study

RESEARCH PAPER

- Prof. Manoranjan Sahu - IITB Environmental Science
- Prof. Jay Dhariwal - IIT Delhi Department of Design
- 20+ Other research paper relevant to study

DESIGN PROJECTS

- Abhinav Saxena, IDC - Outdoor Air Purifier
- Amit Kumar ,IDC - Air Purifier for Mid - Income Group
- Mugdha Dingle, IDC - Bus Stop with Air Purification System

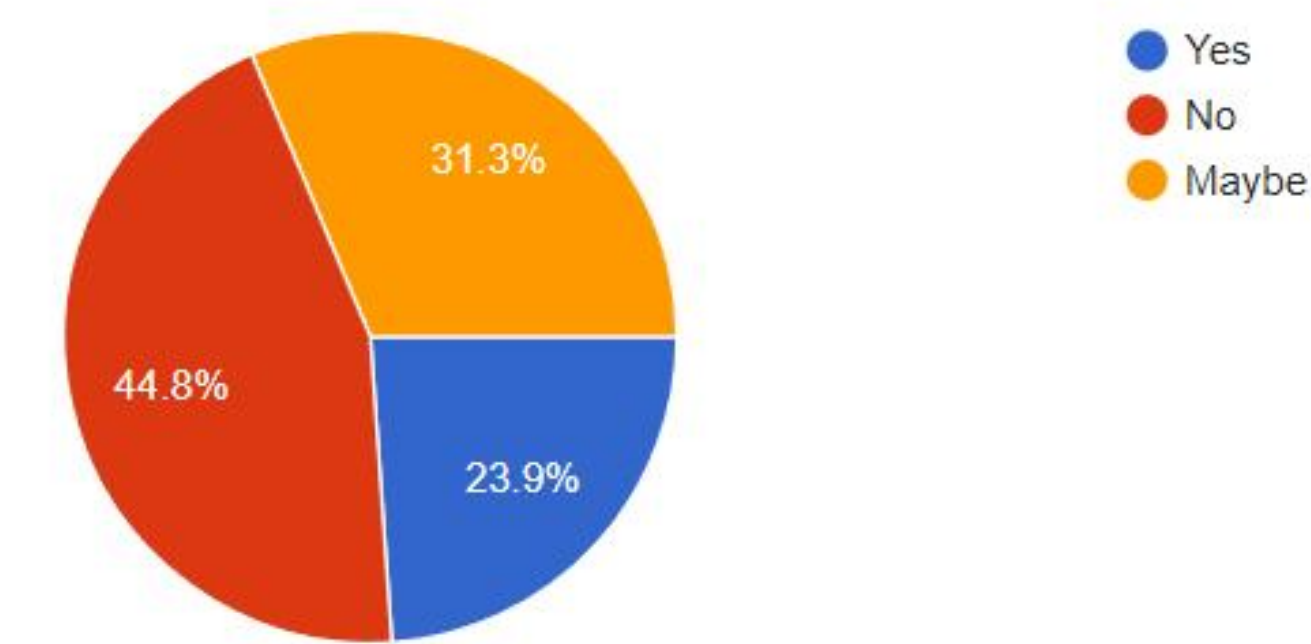
OTHER PROJECTS

Award winning products and technology

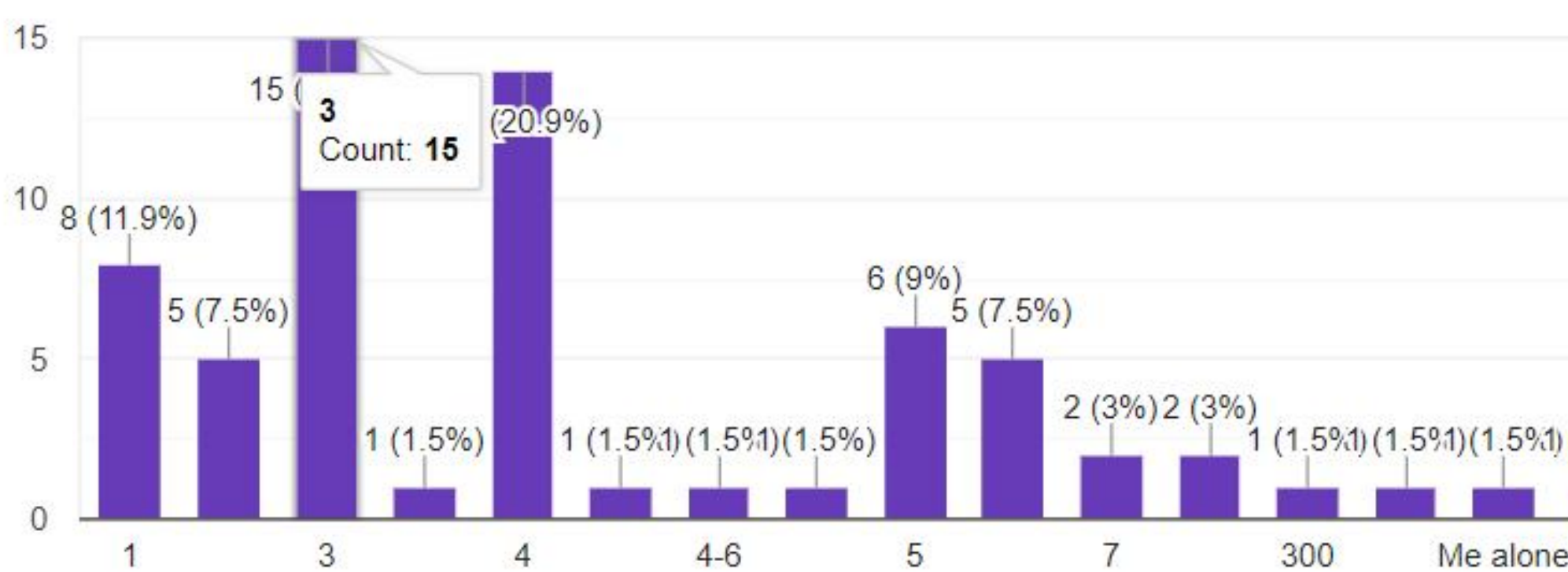
Behance

Online Survey

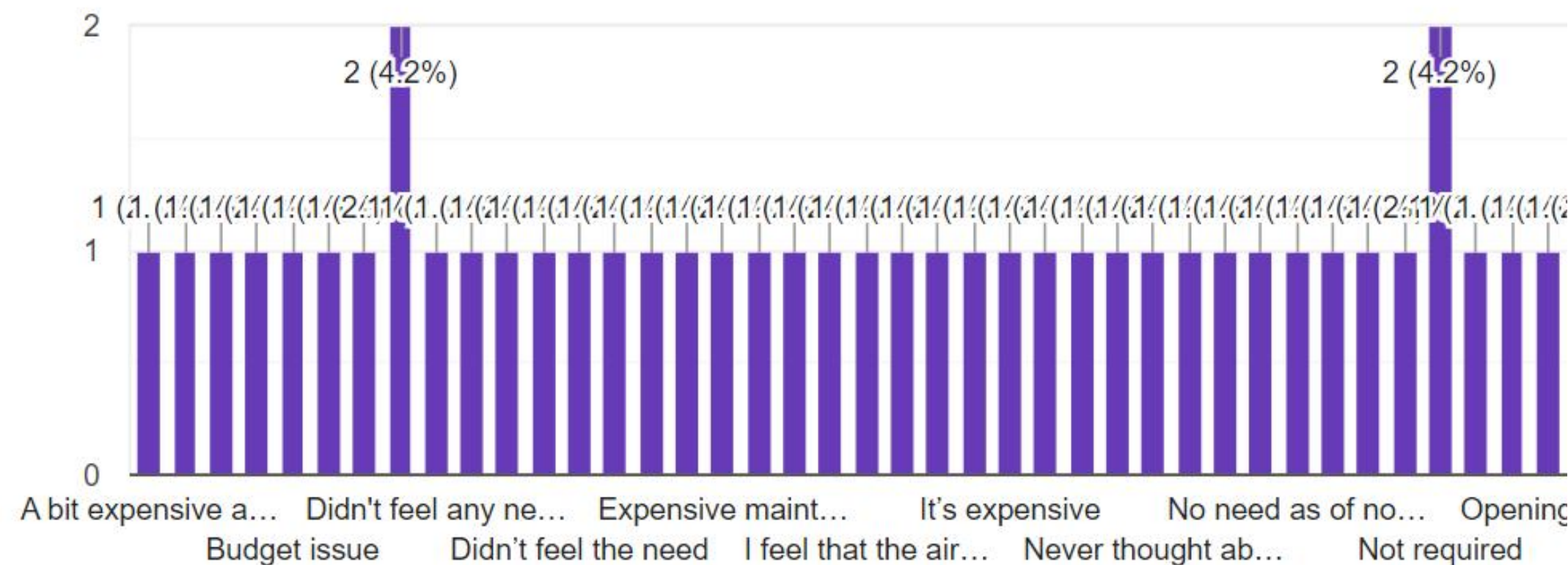
Have you experiences symptoms like sneezing, coughing, or breathing difficulty that you suspect might be due to Indoor Air Quality?



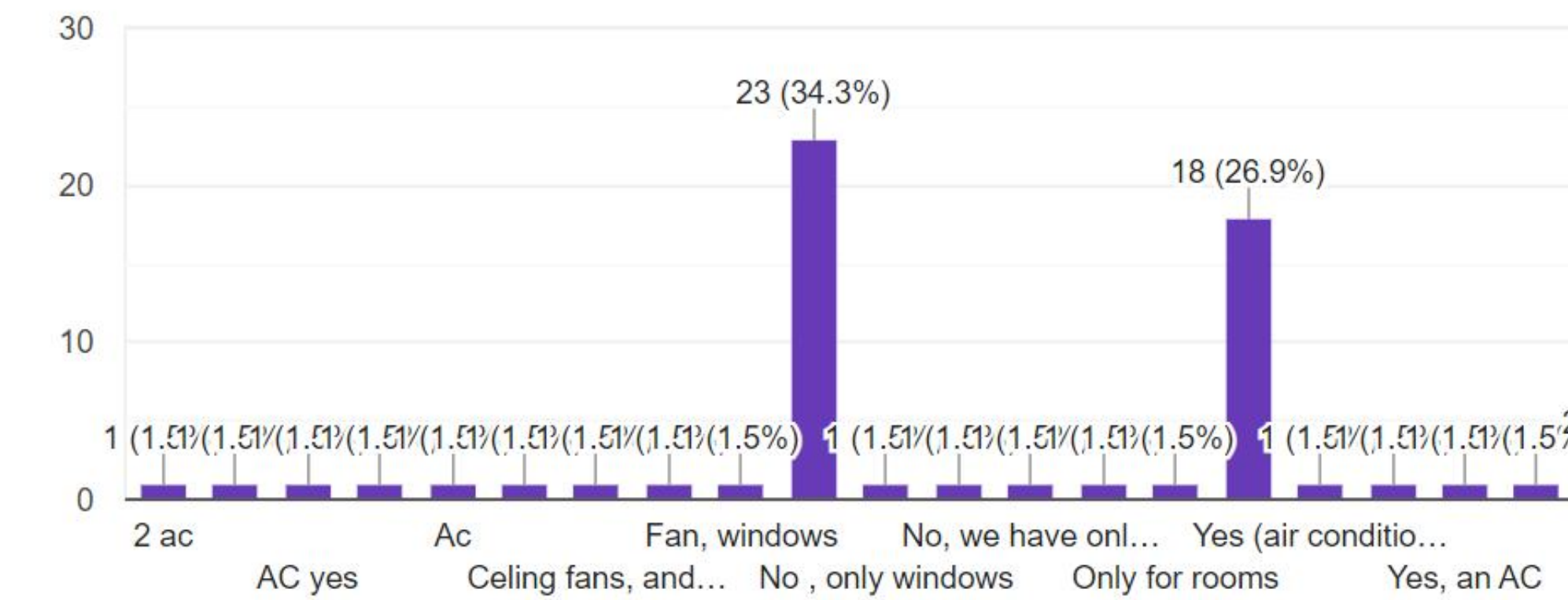
How many people live or work in this place?



Why haven't you purchased an Air Purifier yet?



Is yout place equipped with mechanical ventilating unit like AC / Heater etc?



Personal Interviews

CERCA, IIT Delhi

- Went to Arun Duggal Centre of Excellence for Research in Climate Change and Air Pollution, IIT Delhi
- Met Project Co-ordinator **Hemant Kaushal**
- Went to Department of Design IIT Delhi
- Spoke with PhD Students who were working under the similar field.



Air Purifier User

- Kunal - Salesperson of Air purifier at Reliance digital, Delhi
- Gulshan Kumar- PhD Student at DoD IIT Delhi
- Syam Lal K S (*Online interview*)
- Swati - Mahim, Mumbai

Non Air Purifier Users

- Ayush Pawar - psychology student Delhi (Non Air Purifier User)
- Shivam - Salesperson of Air purifier at Reliance digital, Delhi (Non Air Purifier User)
- Vamsi - PhD Student at DoD IIT Delhi (Non Air Purifier User)

Interview protocols

Interviewing individuals about indoor air pollution had to be a structured protocol to ensure comprehensive and consistent data collection. Here's a interview protocol that I followed:

Introduction:

- Introduce yourself and the purpose of the interview.
- Explain that the interview will focus on indoor air quality and its potential impacts on health and well-being.
- Assure confidentiality and the voluntary nature of participation.

Demographic Information:

- Ask for basic demographic information, such as age, gender, occupation, family size, and location of residence.

Indoor Environment:

1. General Questions:

- How would you describe the indoor environment of your home/workplace?
- What are the primary sources of indoor air pollutants in your living/working space?

2. Ventilation:

- Can you describe the ventilation systems in your home/workplace?
- How often do you open windows and doors to allow fresh air to enter?

3. Heating and Cooling:

- What type of heating and cooling systems do you use?
- How often are these systems maintained?

4. Cleaning and Maintenance:

- How frequently do you clean your living/working space?
- What cleaning products do you typically use?

Awareness and Concerns:

1. Health Perception:

- Are you aware of any health symptoms that might be related to indoor air quality?
- Have you noticed any changes in your health since living/working in this environment?

2. Knowledge of Pollutants:

- Are you familiar with common indoor air pollutants (e.g., tobacco smoke, volatile organic compounds, mold, etc.)?
- Do you know the potential health effects of these pollutants?

Behavior and Practices:

1. Smoking and Combustion:

- Does anyone smoke indoors?
- Are there any appliances that burn fuel indoors (e.g., stoves, heaters)?
- If yes, how do you ensure proper ventilation during and after use?

2. Cleaning Products:

- What type of cleaning products do you use?
- Have you considered using alternative, less toxic cleaning products?

3. Air Fresheners and Scented Products:

- Do you use air fresheners or scented products?
- Are you aware of their potential impact on indoor air quality?

Mitigation Strategies:

- Have you taken any measures to improve indoor air quality?
- Are there any plans to modify your behaviors or living/working environment to reduce indoor air pollution?

Conclusion:

- Thank the participant for their time and insights.
- Offer any additional resources or information about indoor air quality if they're interested.

Site visits

Air Purifier Users

- Went at the user's home who had an air purifier to know more about the user's perspective about the air purifier since they are using it.



Site visits

Air Purifier Users

- While interviewing, a lot of things were observed including how they use an air purifier, how they clean it and operate the interface. The questions were mostly open ended type which allowed them to speak more about their concerns and beliefs on the use of an air purifier.

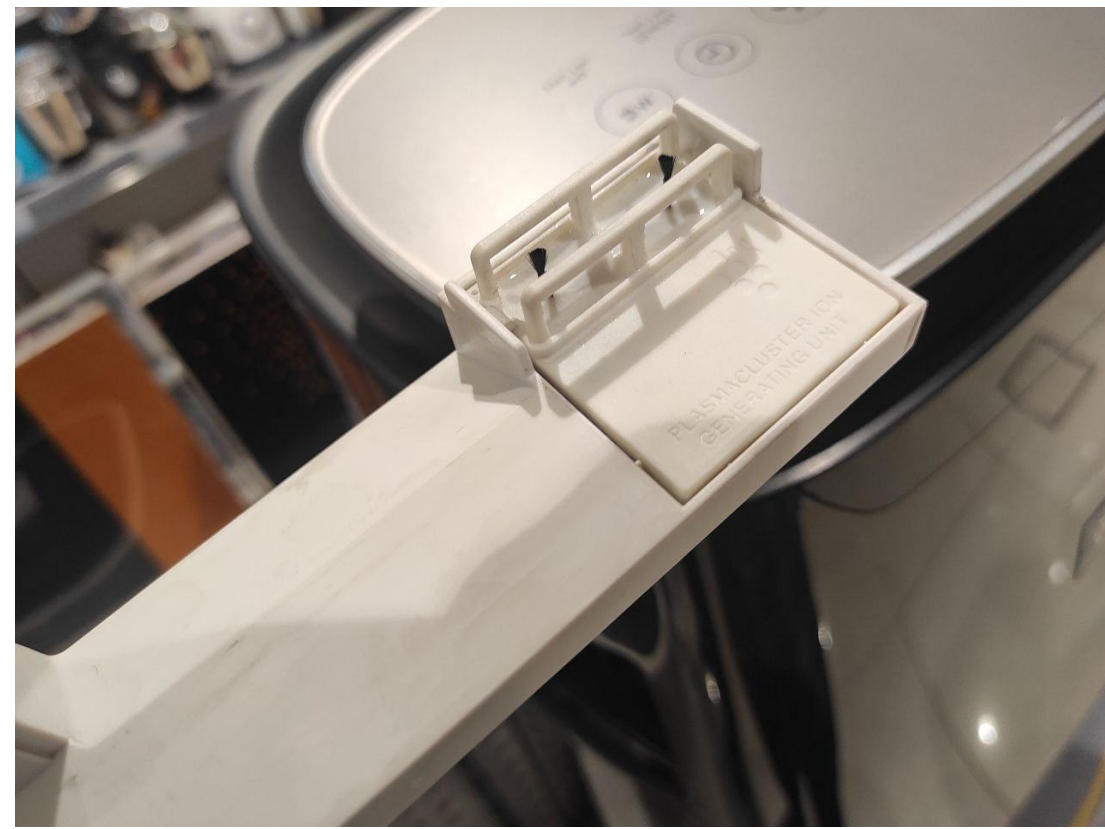


Purifier Cleaning



Room ventilation

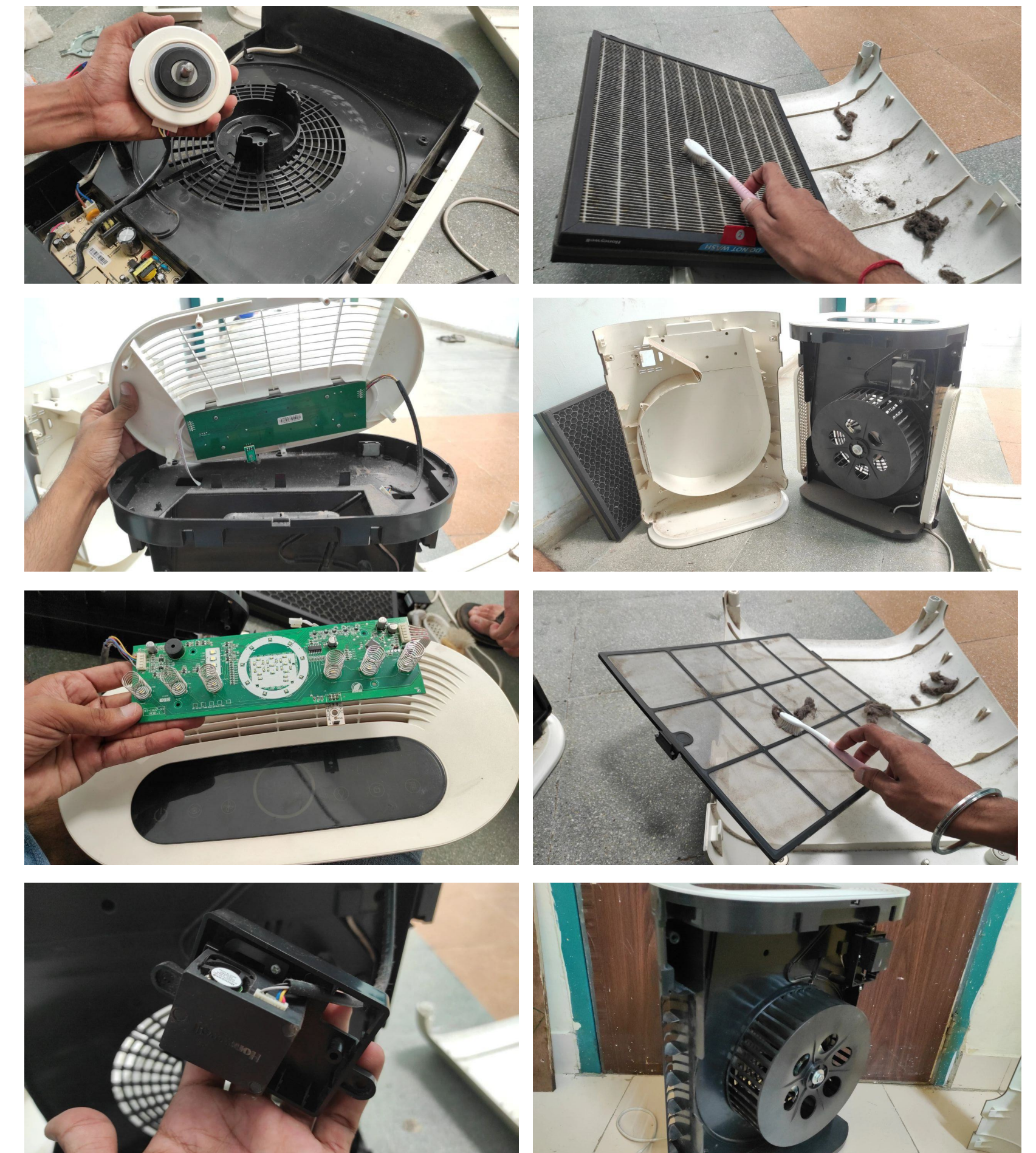
Market visit



Market visit



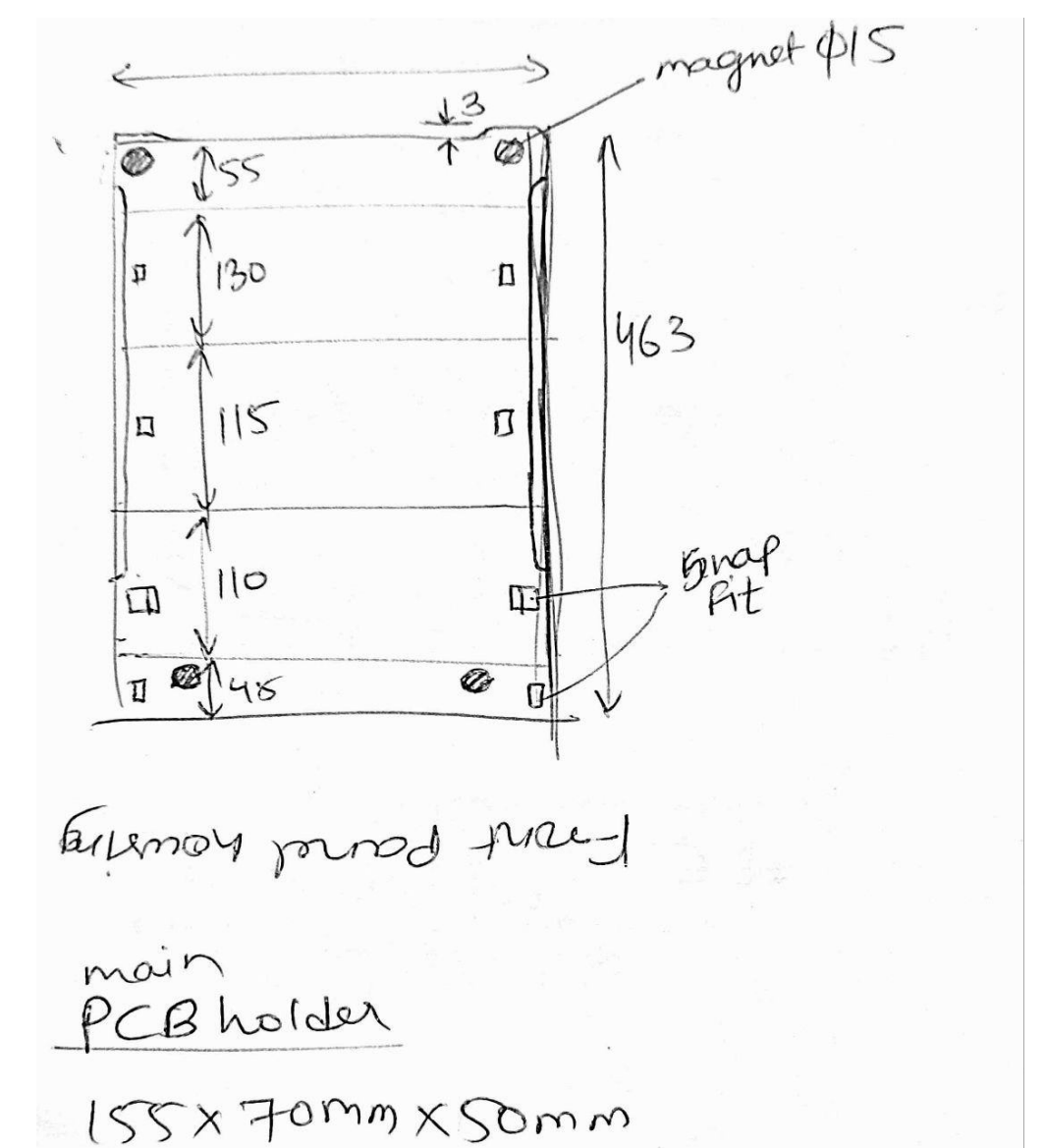
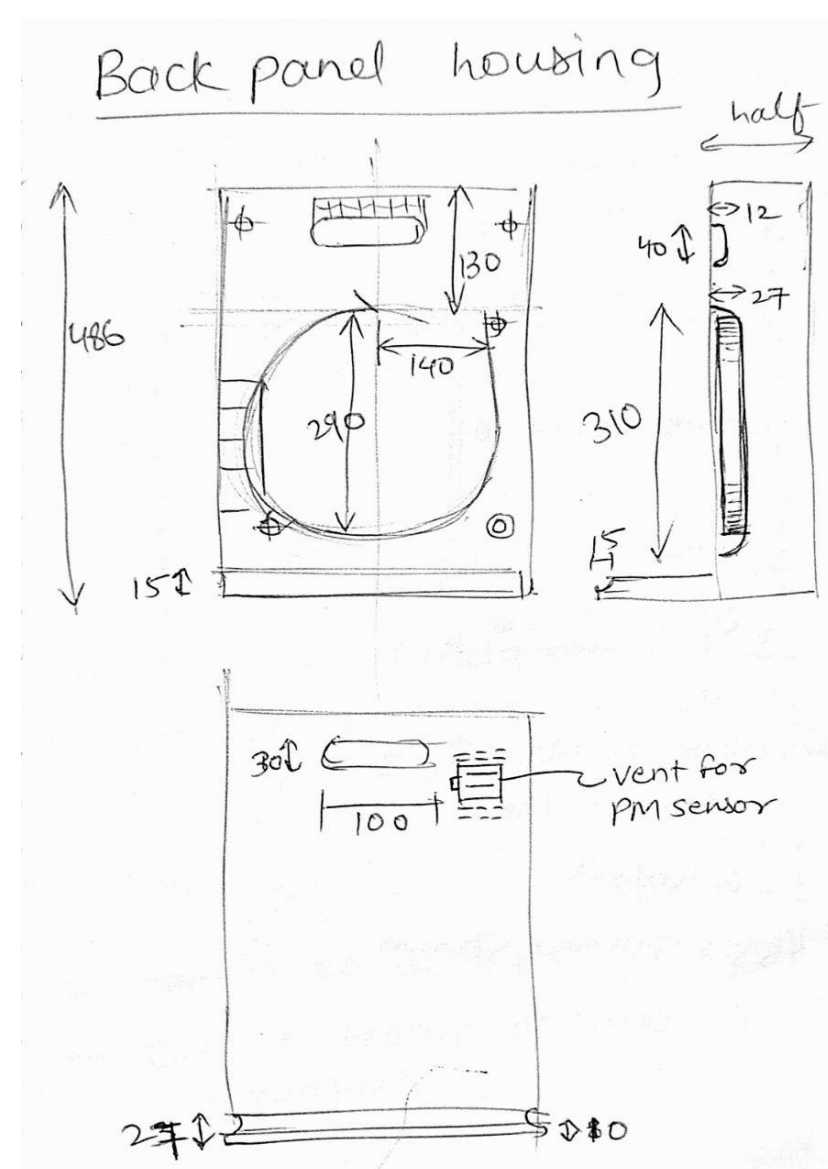
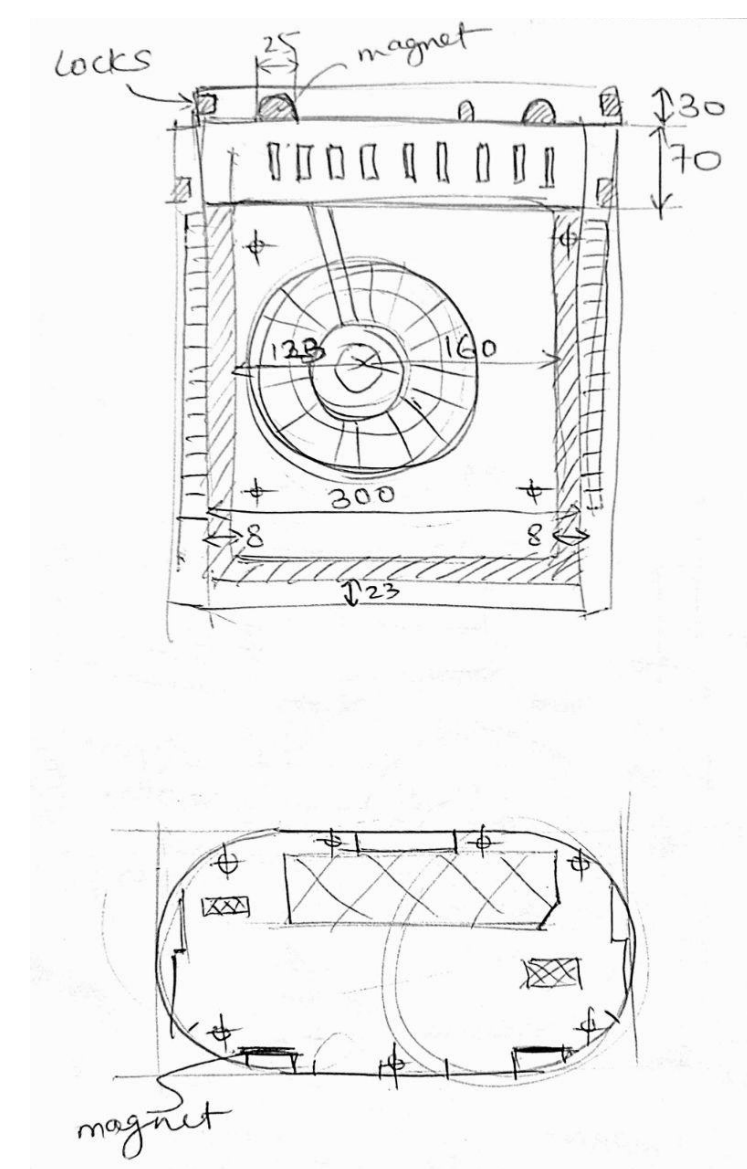
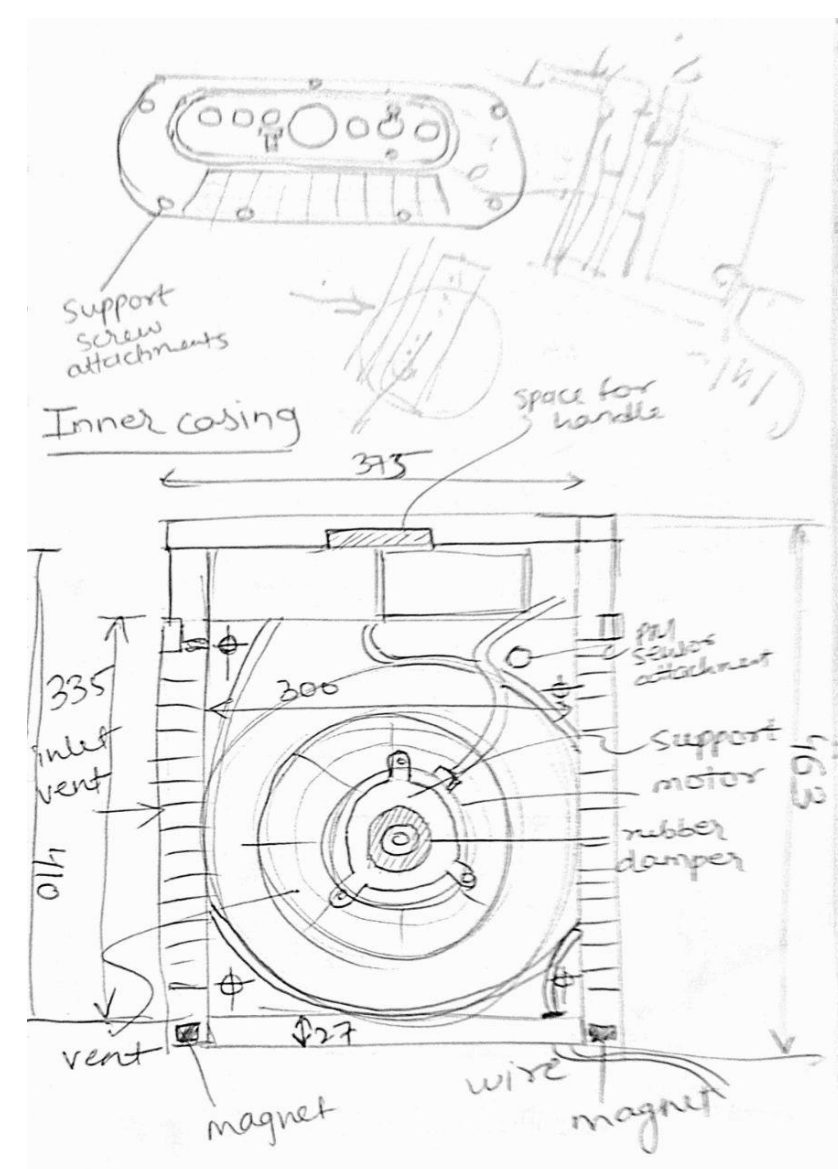
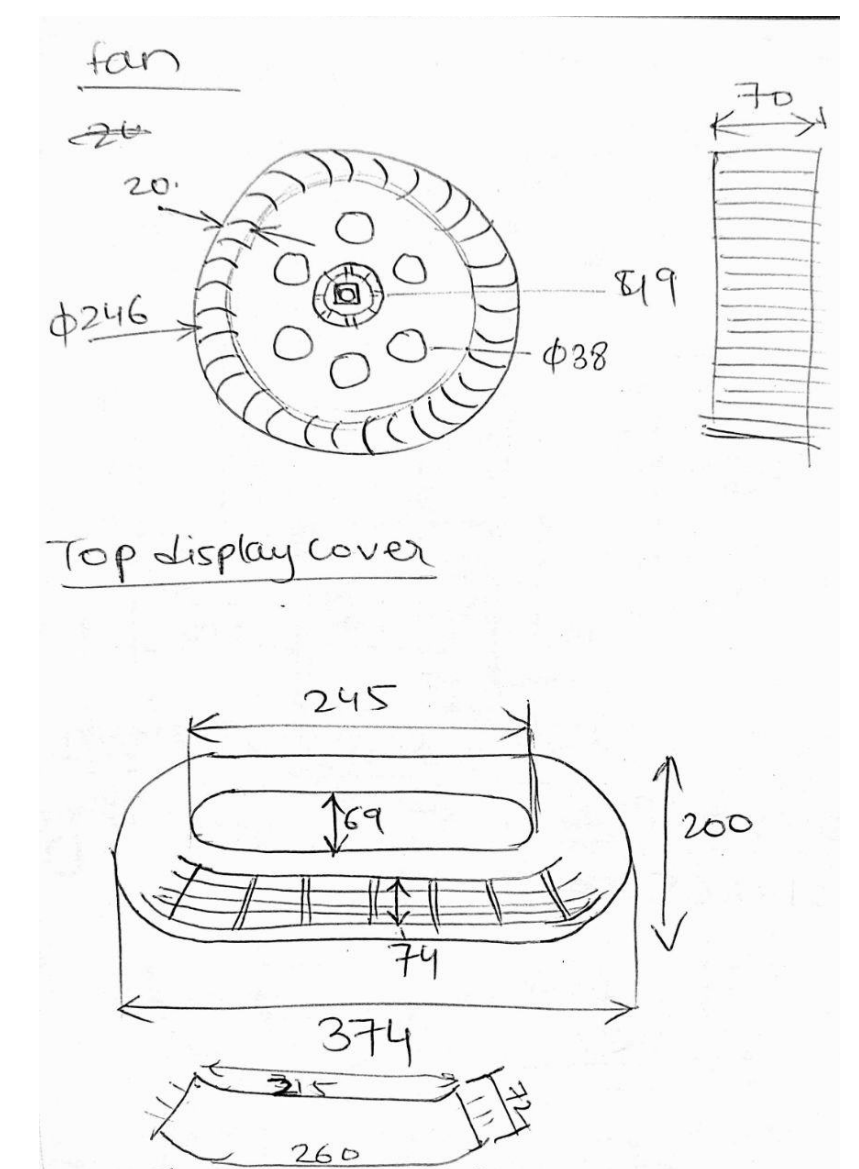
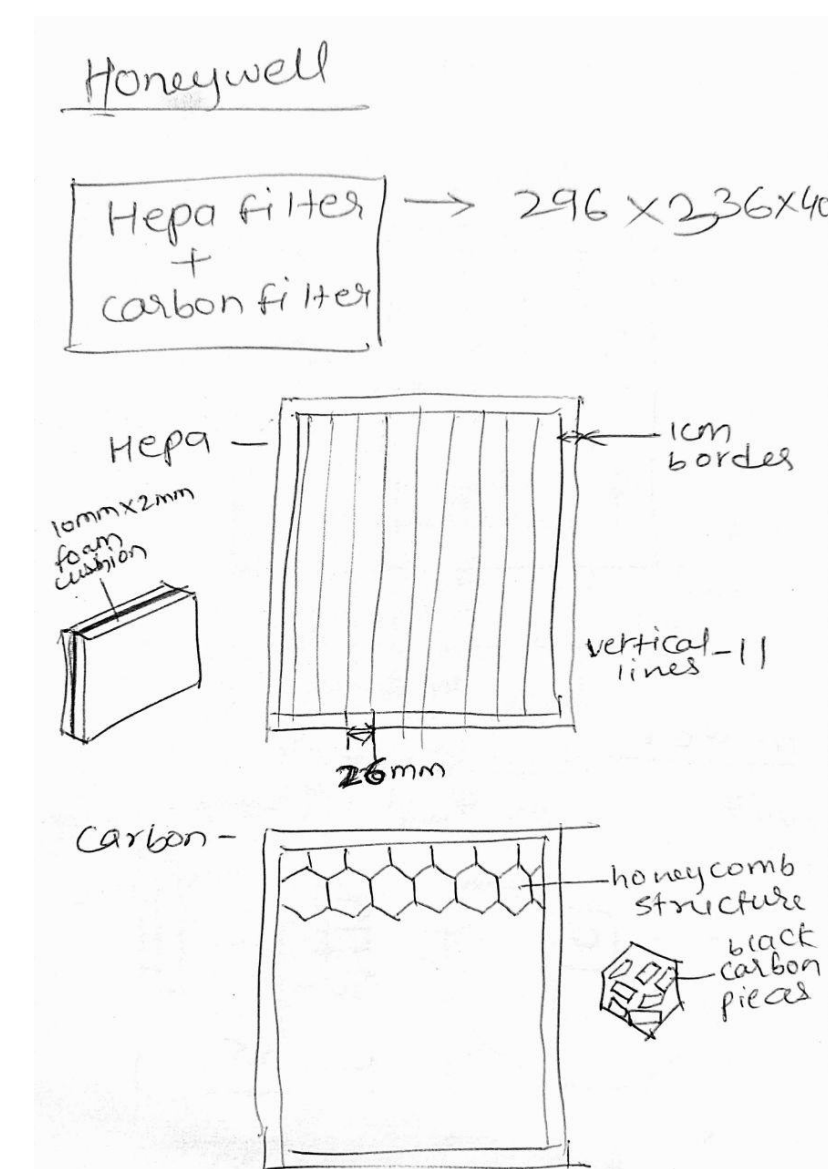
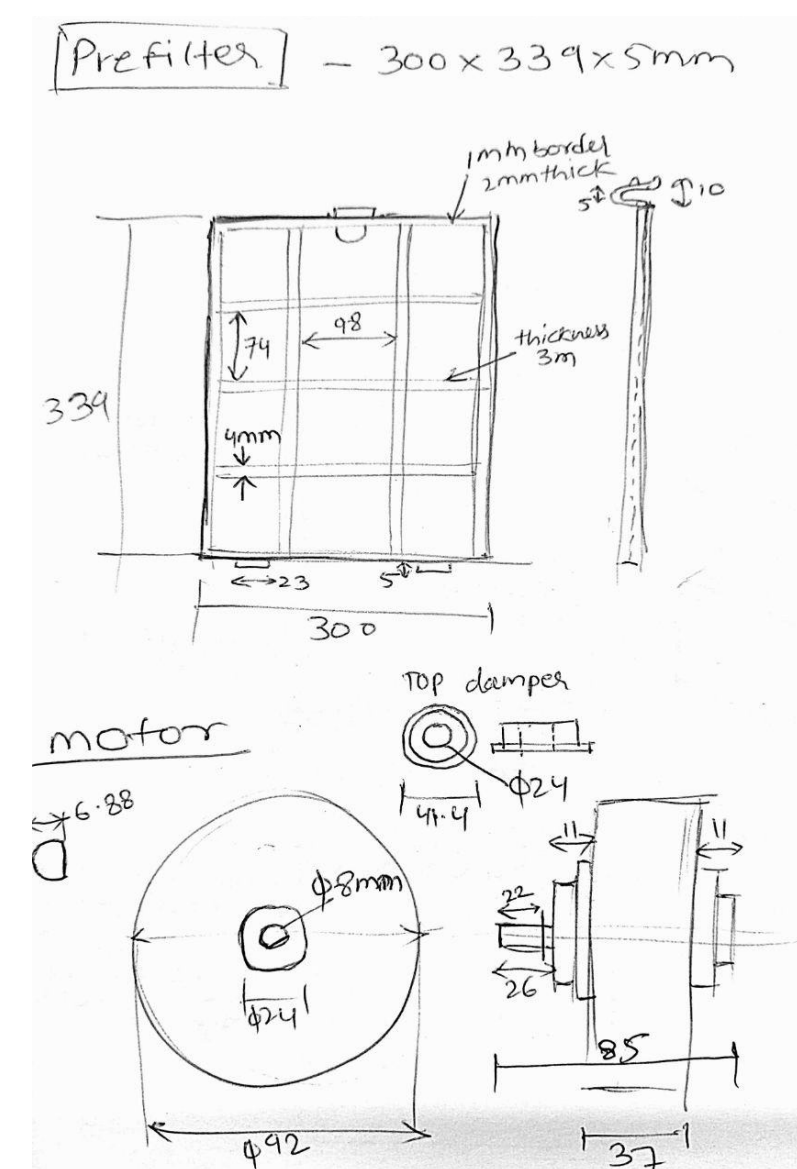
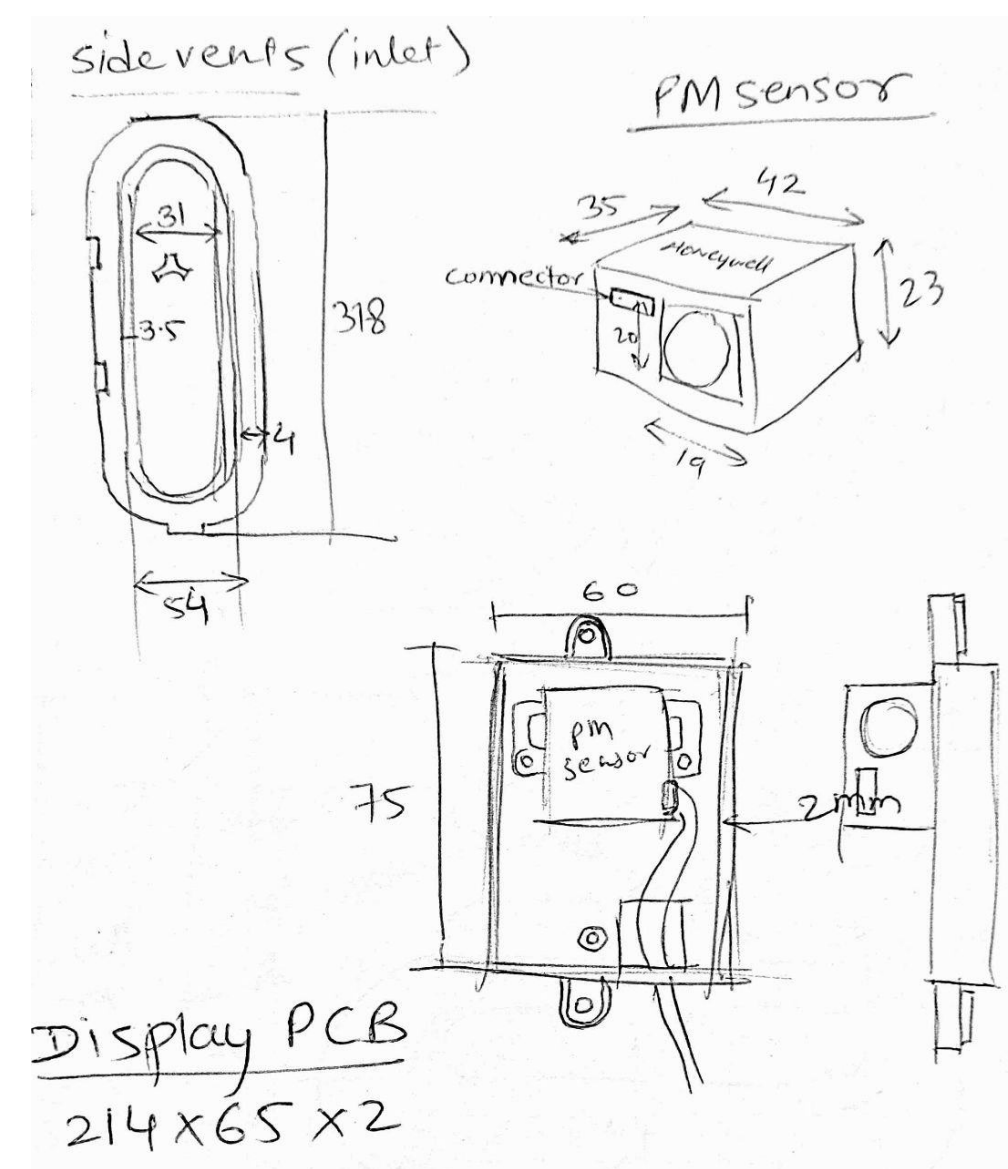
Product disassembly



Product details

Honeywell HAC30M1401G Portable Room Air Purifier (Gold)
Clean Air Delivery Rate - 300 CMH
Power Consumption - 42 W
Noise Level - 63 dB

Component drawing

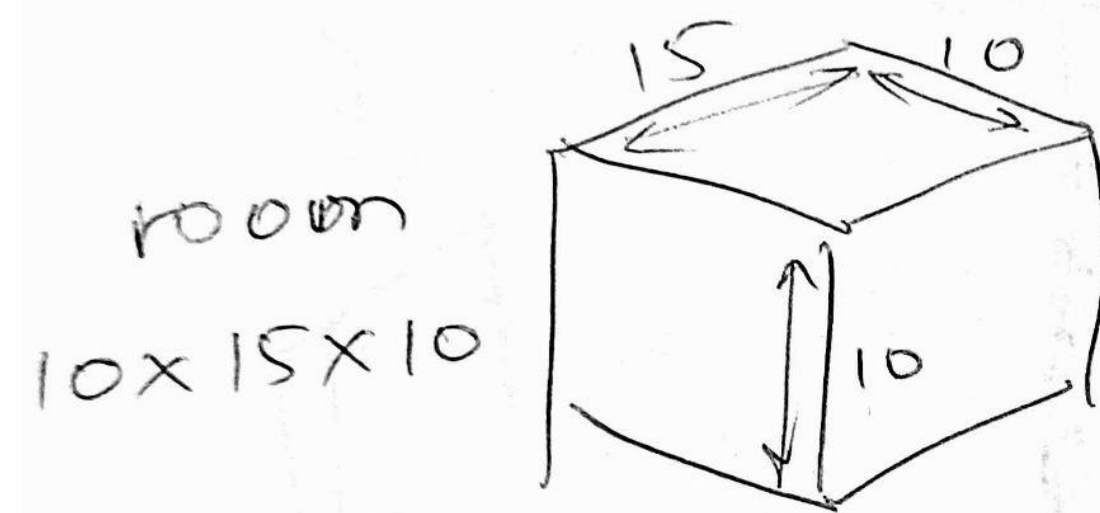


Calculations

Coverage Area (CA) = 150 sqft

ceiling height (h) = 10ft

Air changes per hour (ACH) = 5



$$CADR = \frac{(ACH \times CA \times H)}{60}$$

$$= \frac{5 \times 150 \times 10}{60}$$

$$= 125 \text{ cubic ft/min}$$

$$= 125 \times (0.3048)^3 \text{ m}^3/\text{min}$$

$$= 125 \times (0.3048)^3 \times 60 \text{ m}^3/\text{hr}$$

$$= 212.38 \text{ m}^3/\text{hr}$$

$$\boxed{CADR = 212.38 \text{ m}^3/\text{hr}}$$

$$CADR = \frac{\text{Area at outlet} \times \text{velocity at outlet}}$$

$$\text{air flow velocity} = \frac{\text{air volume of fan (cfm)}}{\text{surface Area of air filter (sqft)}}$$

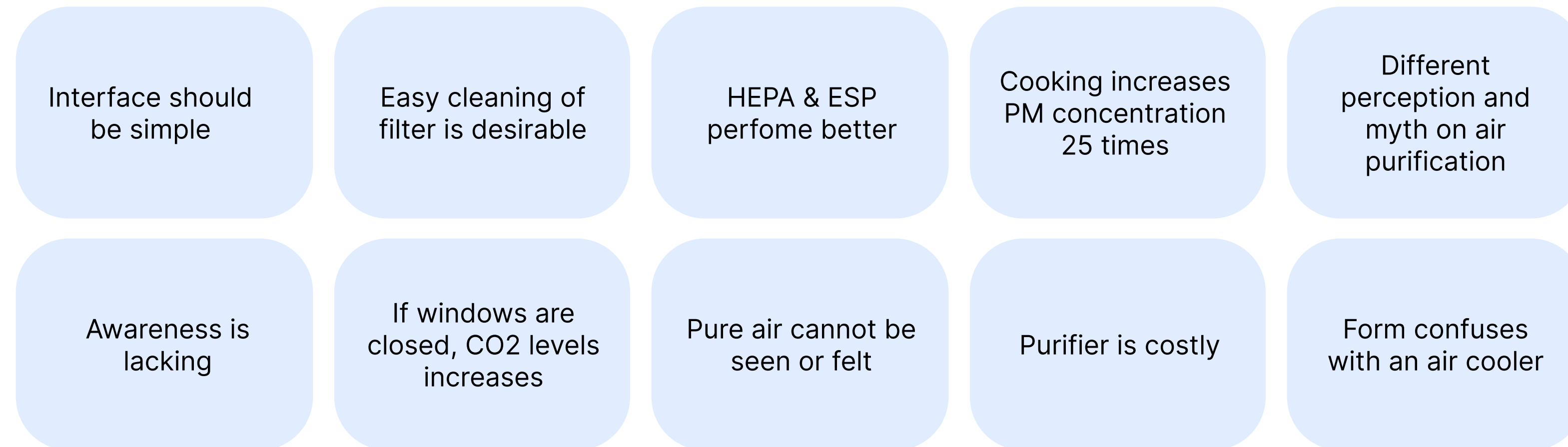
$$= \frac{200}{0.78}$$

$$= 256.4 \text{ Fpm}$$

Research Insights

User perception matters more than Technology	For sake of Thermal comfort, Ventilation is closed	Looks like an Air Cooler	Awareness is not there	People dont know the PROS & CONS	Purchased after falling sick due to Air borne disease	Air purifier has become an aesthetic element	AC purifies air is a myth
While cooking, it feels suffocating and hot	Chimneys are costly & Exhaust fan are less effective	CO2 level rises if windows are closed	No visual or tangible feedback from Air Purifier	Increase in CO2 leads to cognitive disorders	Purchased because of new born baby	Basic desk research before purchasing	Pure Air cannot be felt or seen
Air curtains are used in malls to prevent PM particles	Government subsidy should be there	Bring an ADDON instead of launching a new product	Small/ Portable Air purifier would be good	Mechanical filters get clogged which increase energy consumption	Clearance of 20cm is required from all sides	Room freshners improves air quality is a user perception	Ventilated room with air purifier is good
Indian houses have space constraints and cost constraints	Cleanable filters are desirable	PM2.5 sensors are always imported	Outlet is at the Top, small things can enter	ESP can be safely operated at high temperature	lonsisers / ESP should be avoided for asthamatic, elderly and kids	Air changes per hour should be atleast 5 times	All side suction helps in purifying air quickly
ESP is economical & low maintenance	VOCs are generated from cooking, smoking and room cleaning	Cooking increases PM concentration for upto 27 times	Womens & childrens are the most affected people due to IAP	Using air purifier might create a habit for fresh air	Cooking & Smoking are major source of IAP	Cost of air purifier is more	CADR is highest in HEPA followed by ESP

Key insights



Design Intervention

Design for purifying cooking space

Cooking activities generate high level PM particles and also increase the CO2 levels upto 27 times which might lead to respiratory disease as well as cognitive disorders.

Design for maintaining the CO2 levels

For the sake of thermal comfort, we close the windows while turning ON an AC or heater... this leads to increase in CO2 levels which may lead to cognitive disorders.

Design for behavioral change.

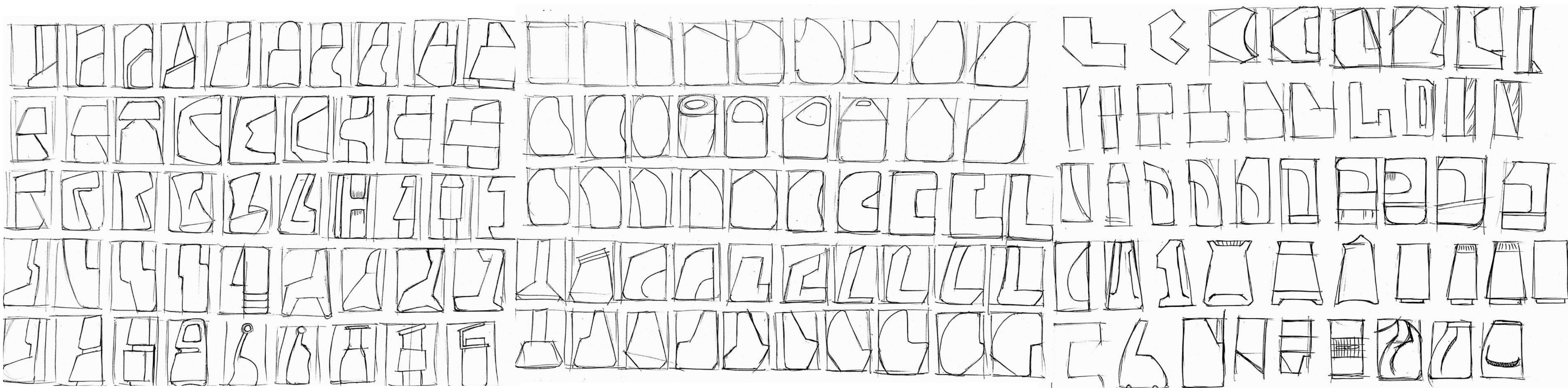
Pure or bad air cannot be felt or seen unlike pure water... people might tend to buy it if they get aware of the air quality. awareness of air purifier is a major challenge.

Design Brief

To design a product which enhances the experience of the user such that they tend to use an air purifier more often. The product should be so intuitive that people tend to ask more about the product thereby spreading awareness.

Ideation

2D Form Exploration



Design Consideration

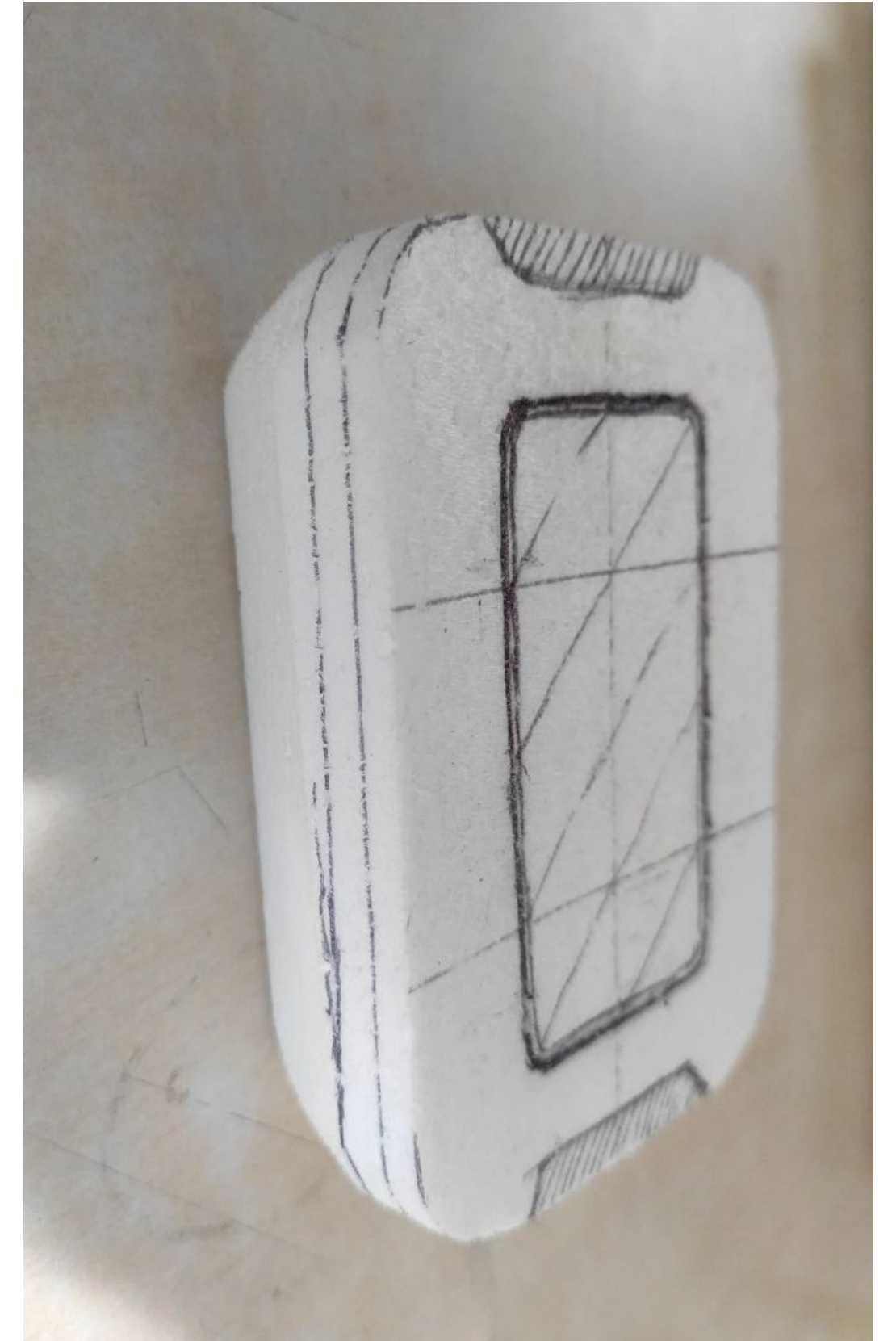
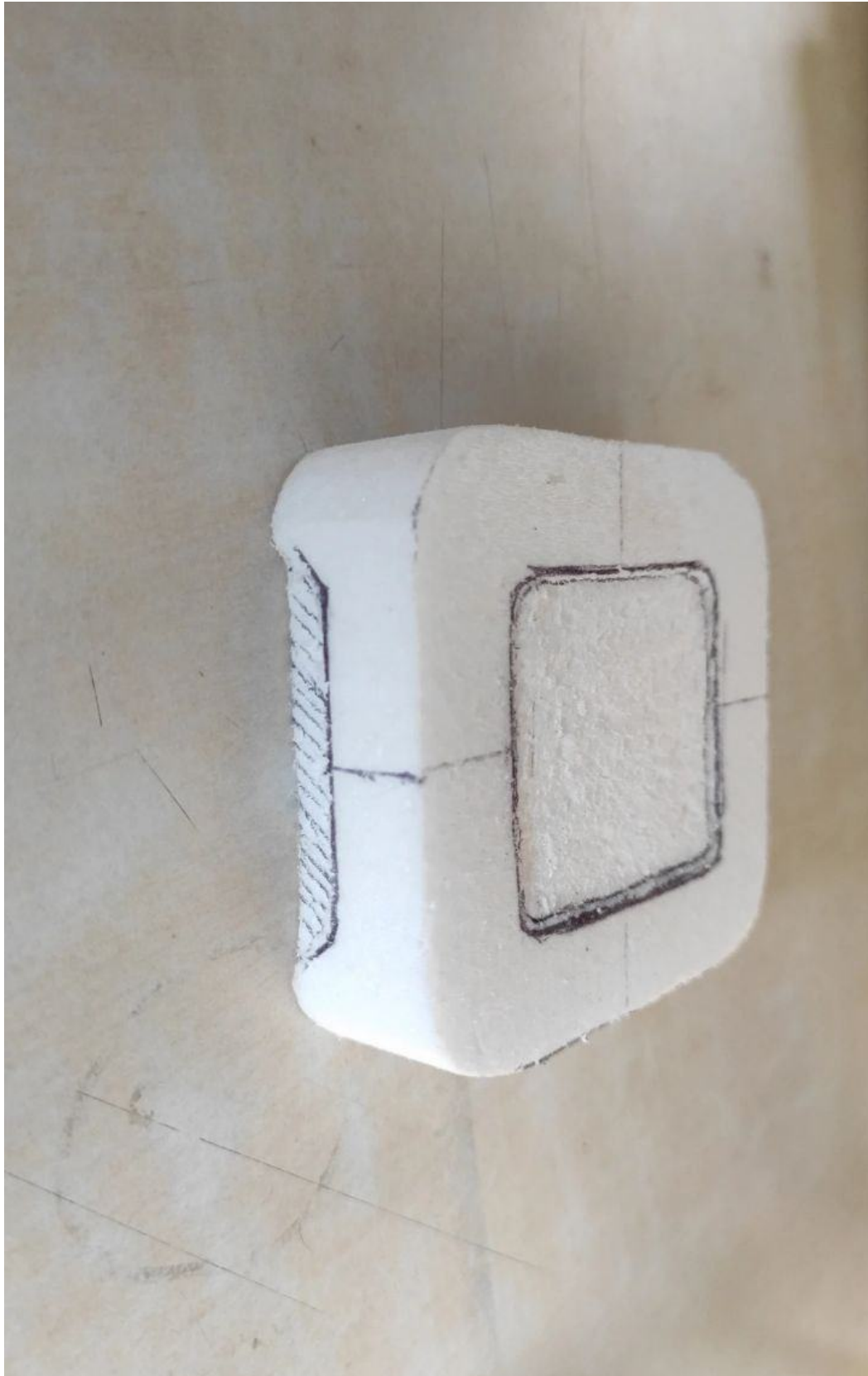
- User friendly
- Ease of cleaning
- Portability
- Intuitive
- Aesthetic

Ideation

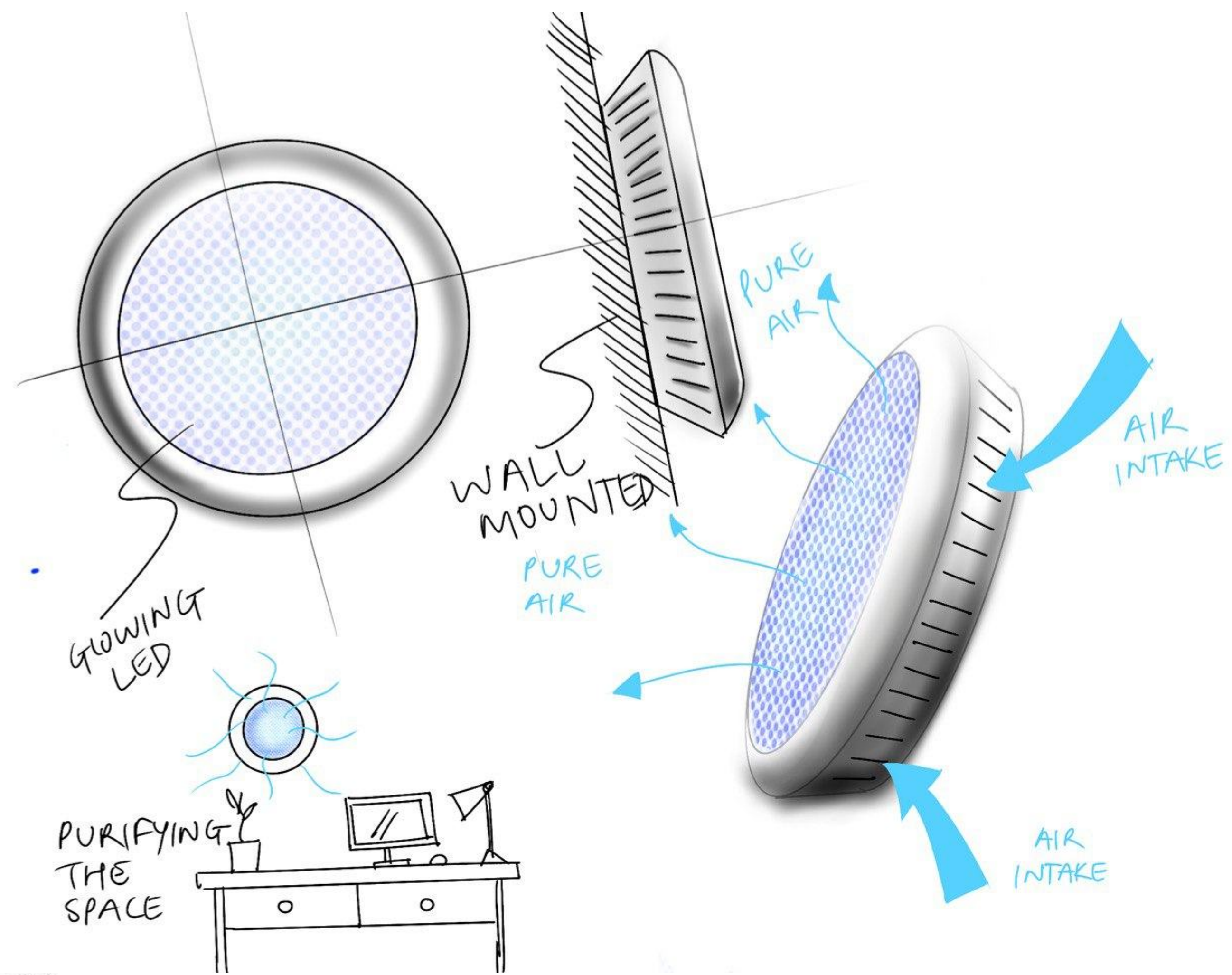
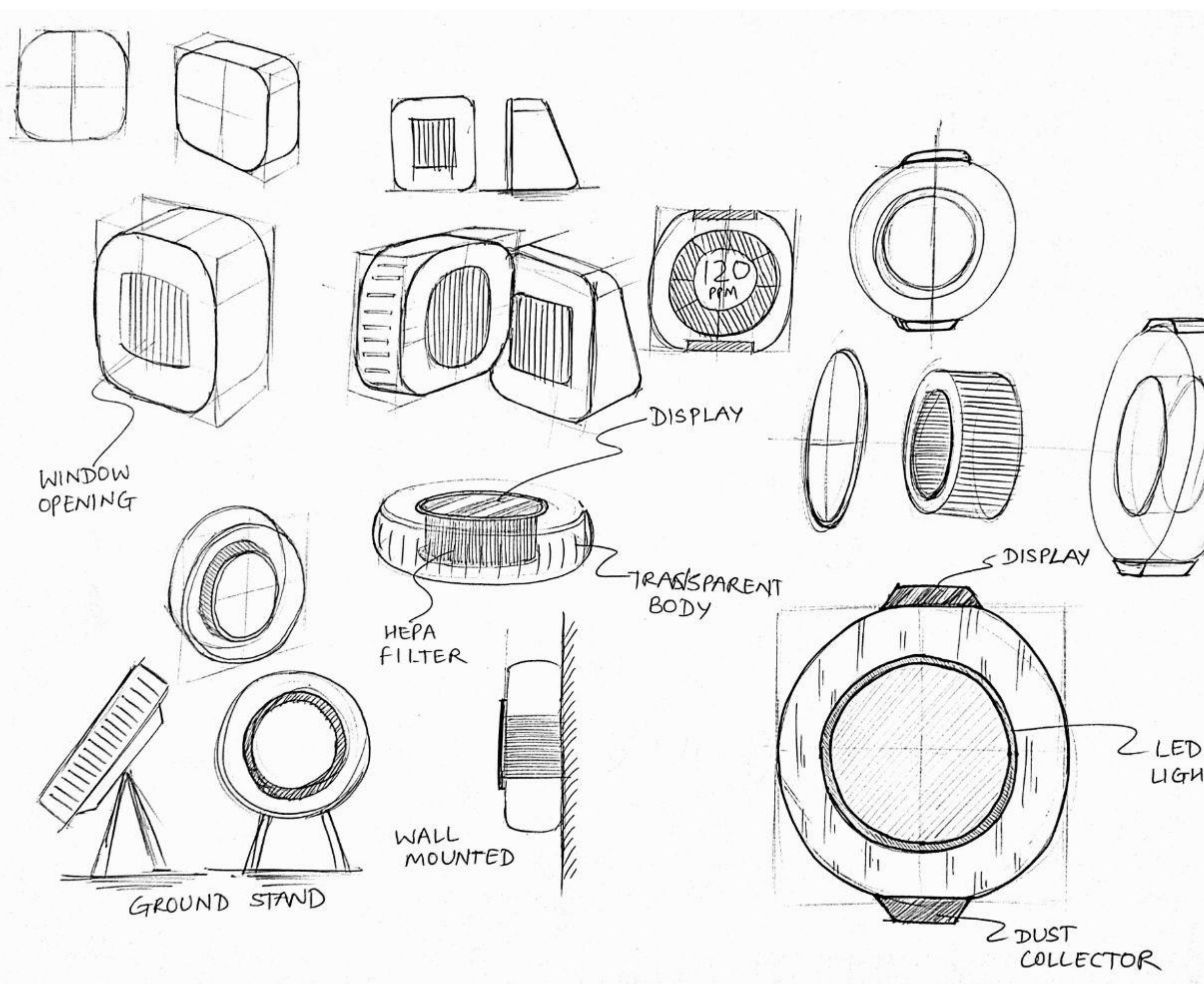
3D Form Exploration



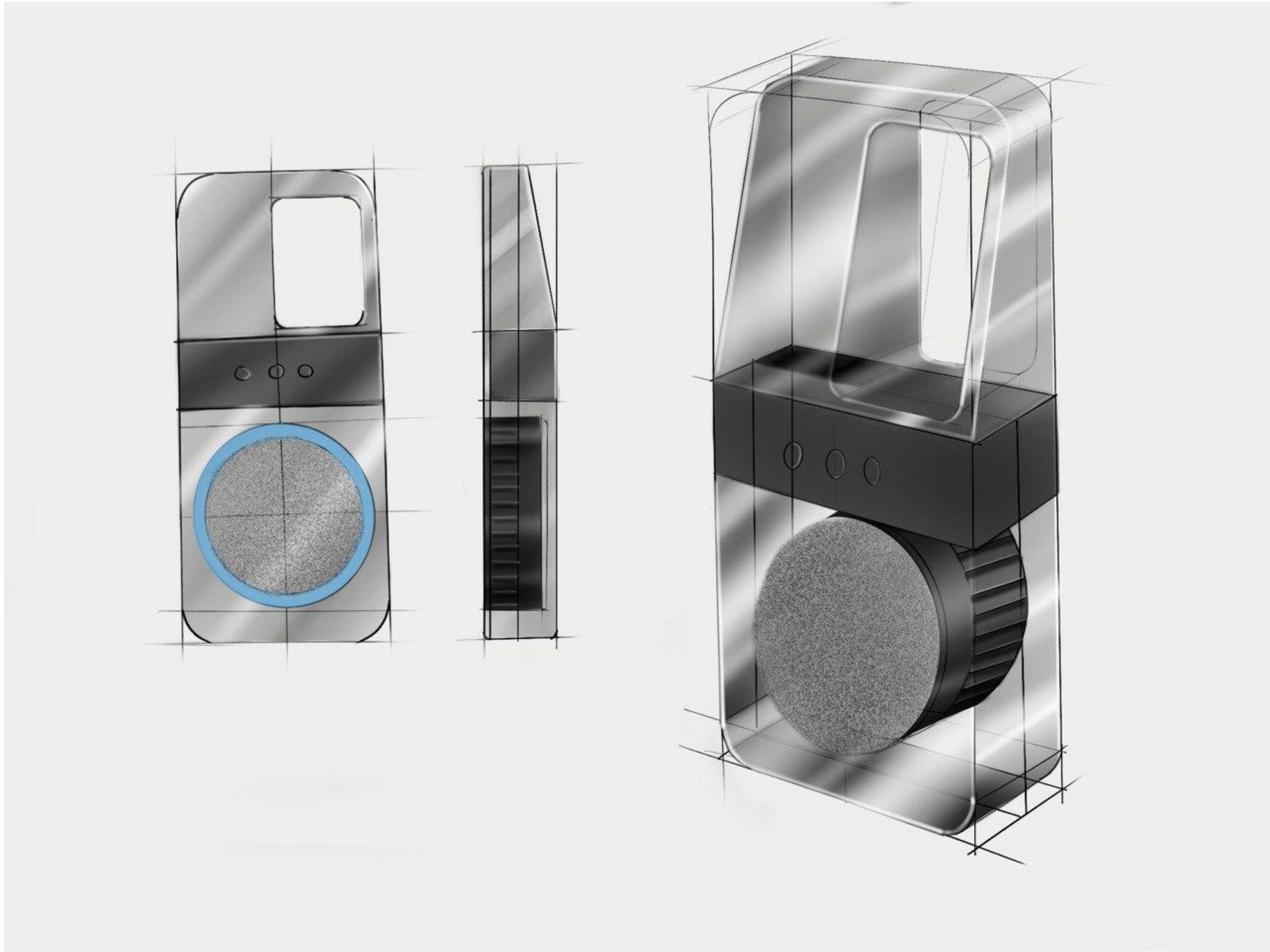
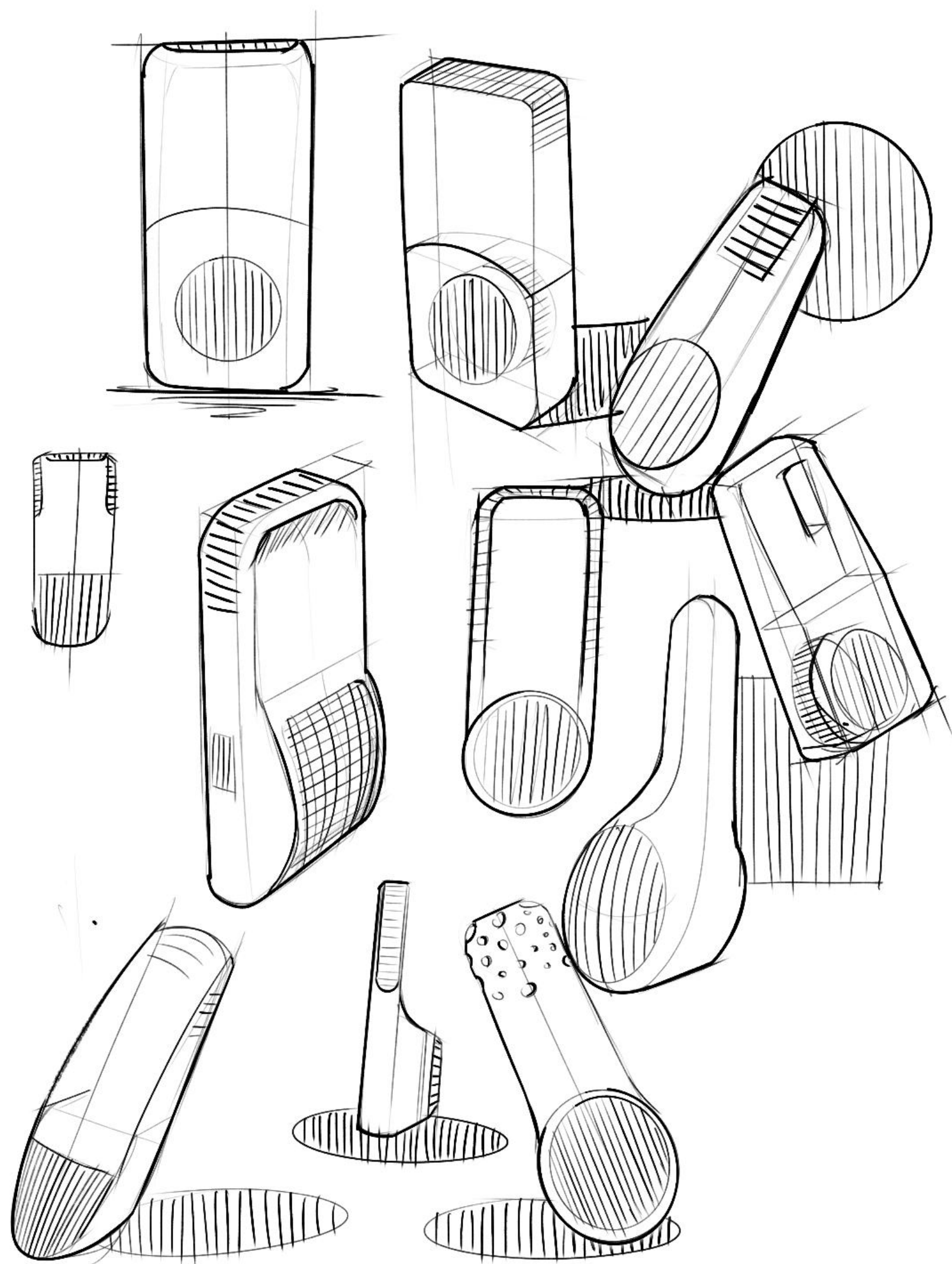
Mockups



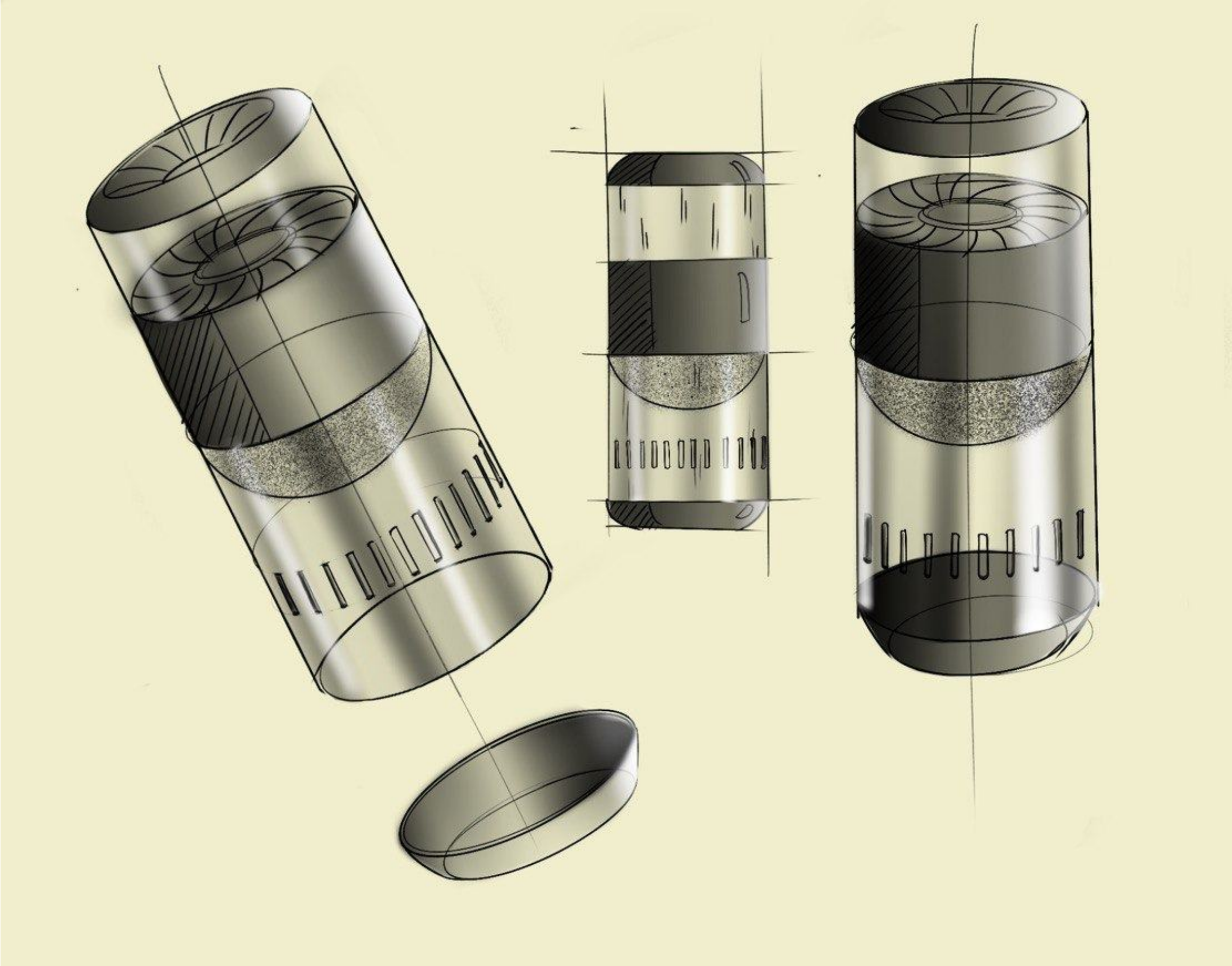
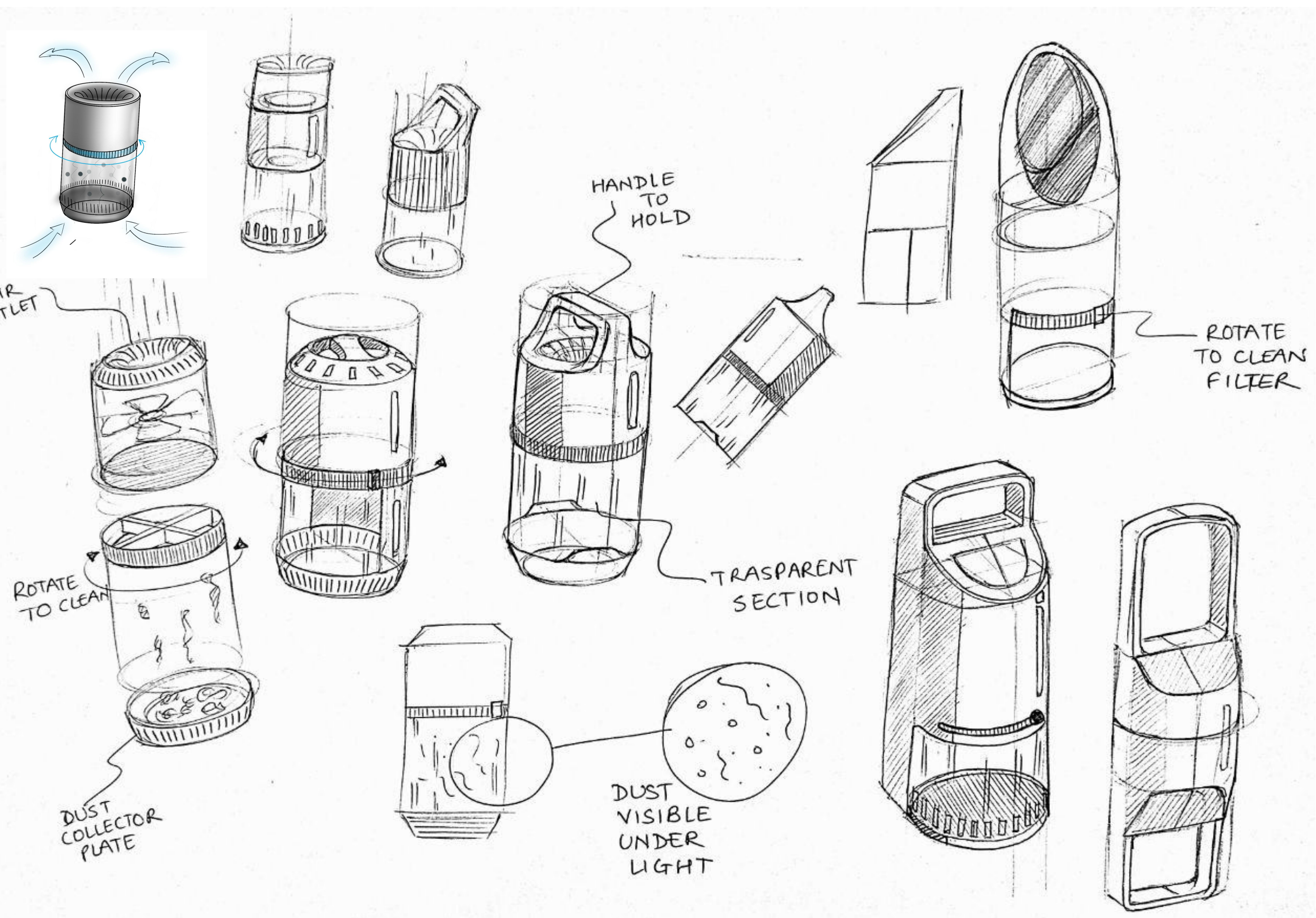
Concept 01



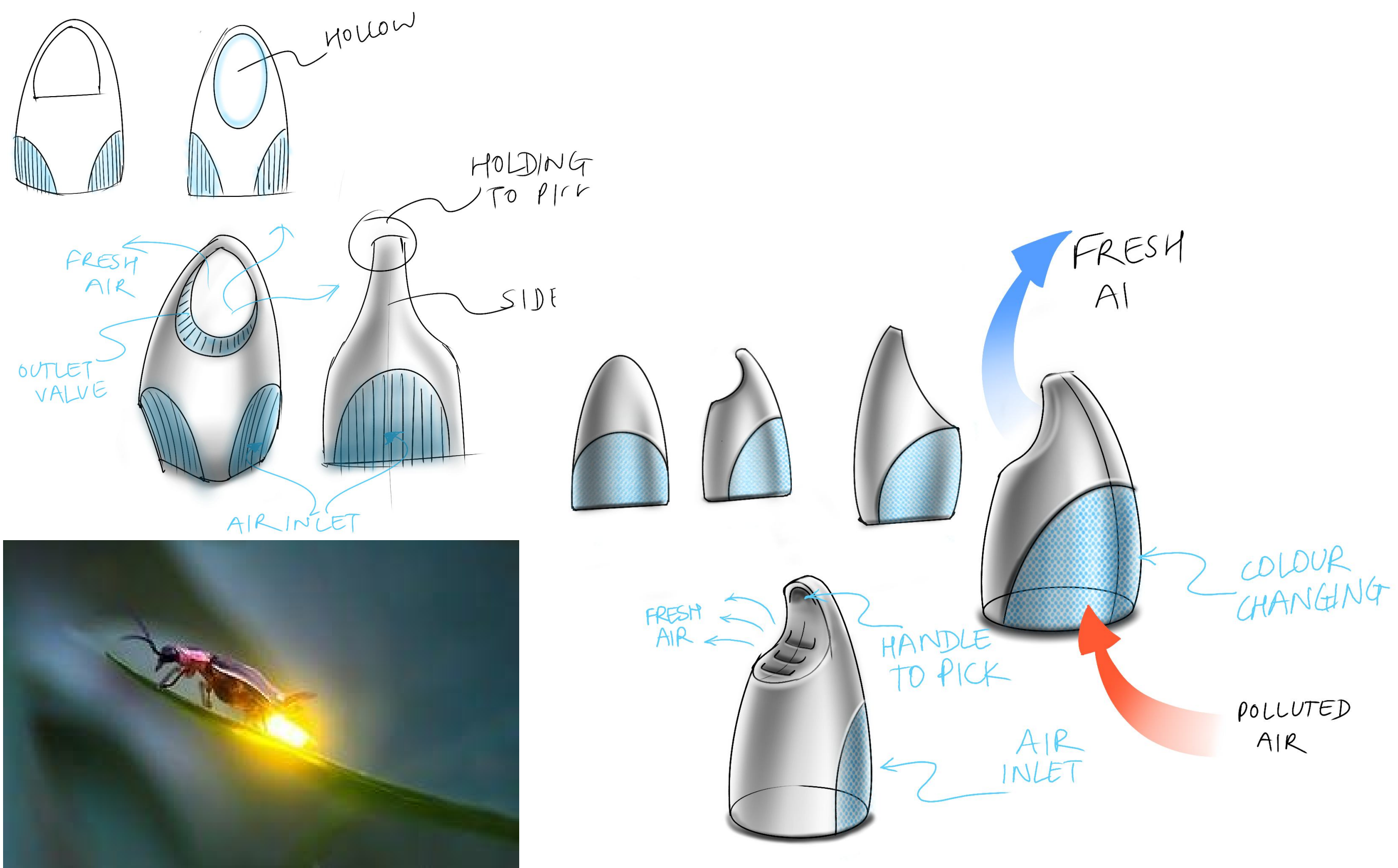
Concept 02



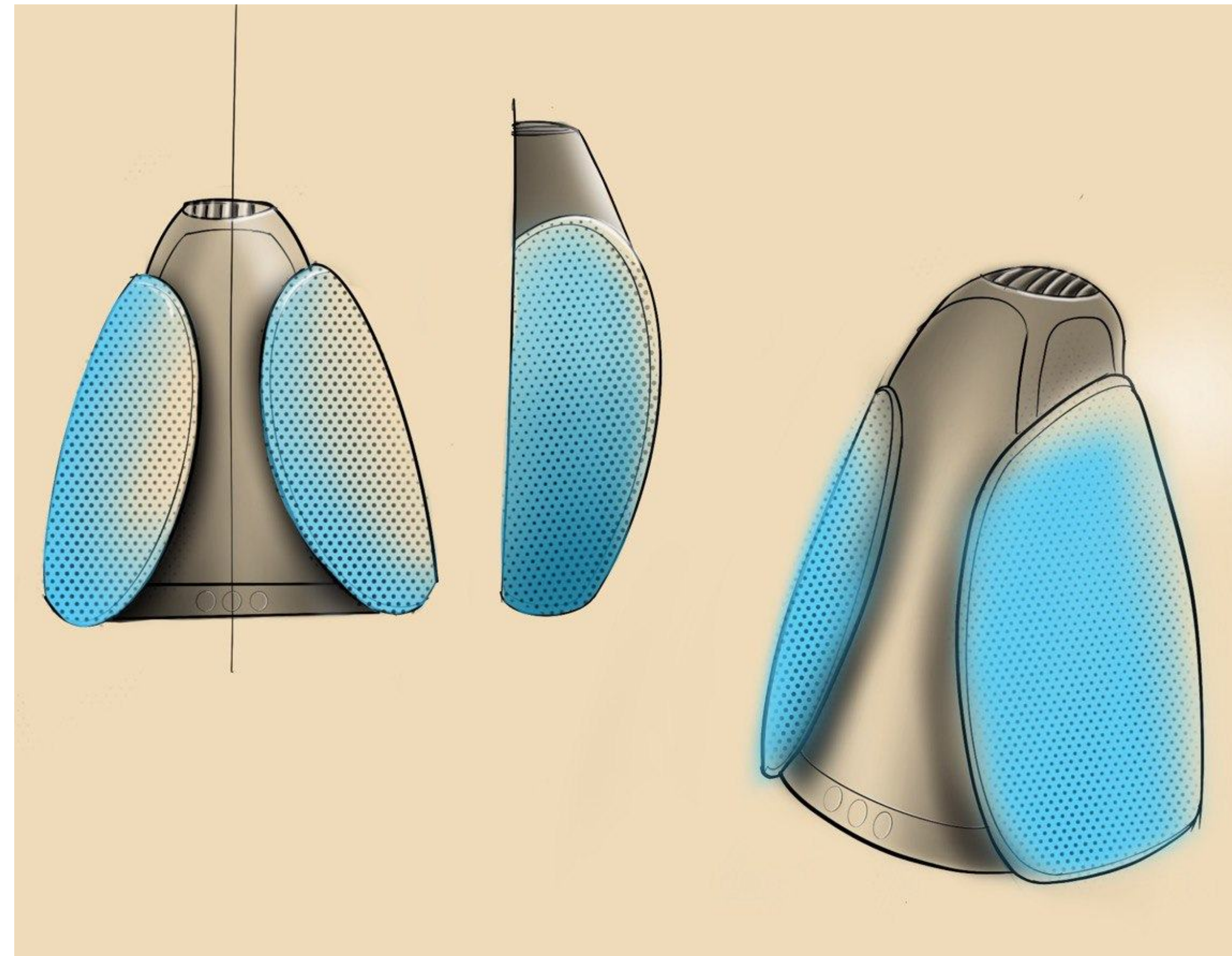
Concept 03



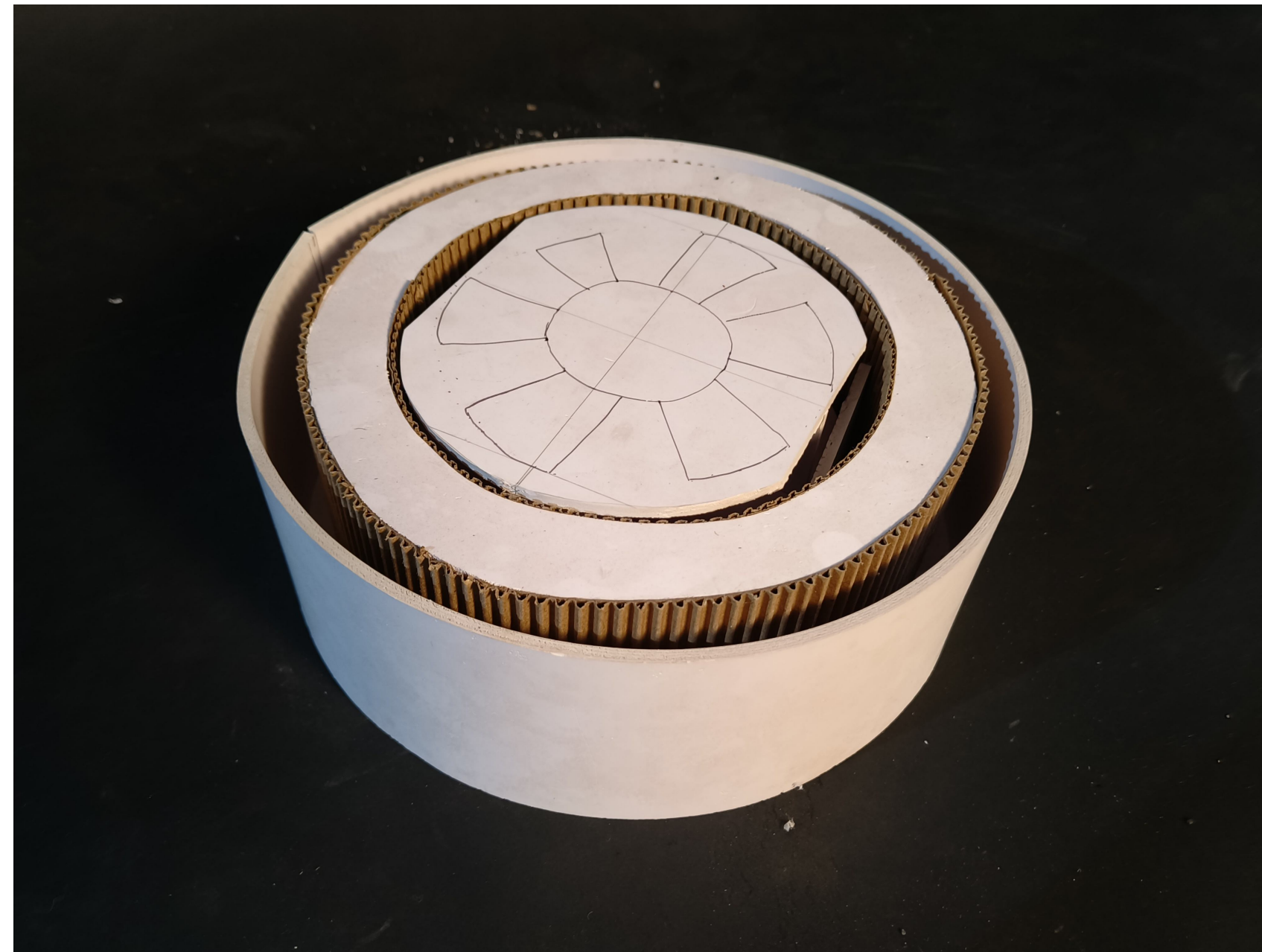
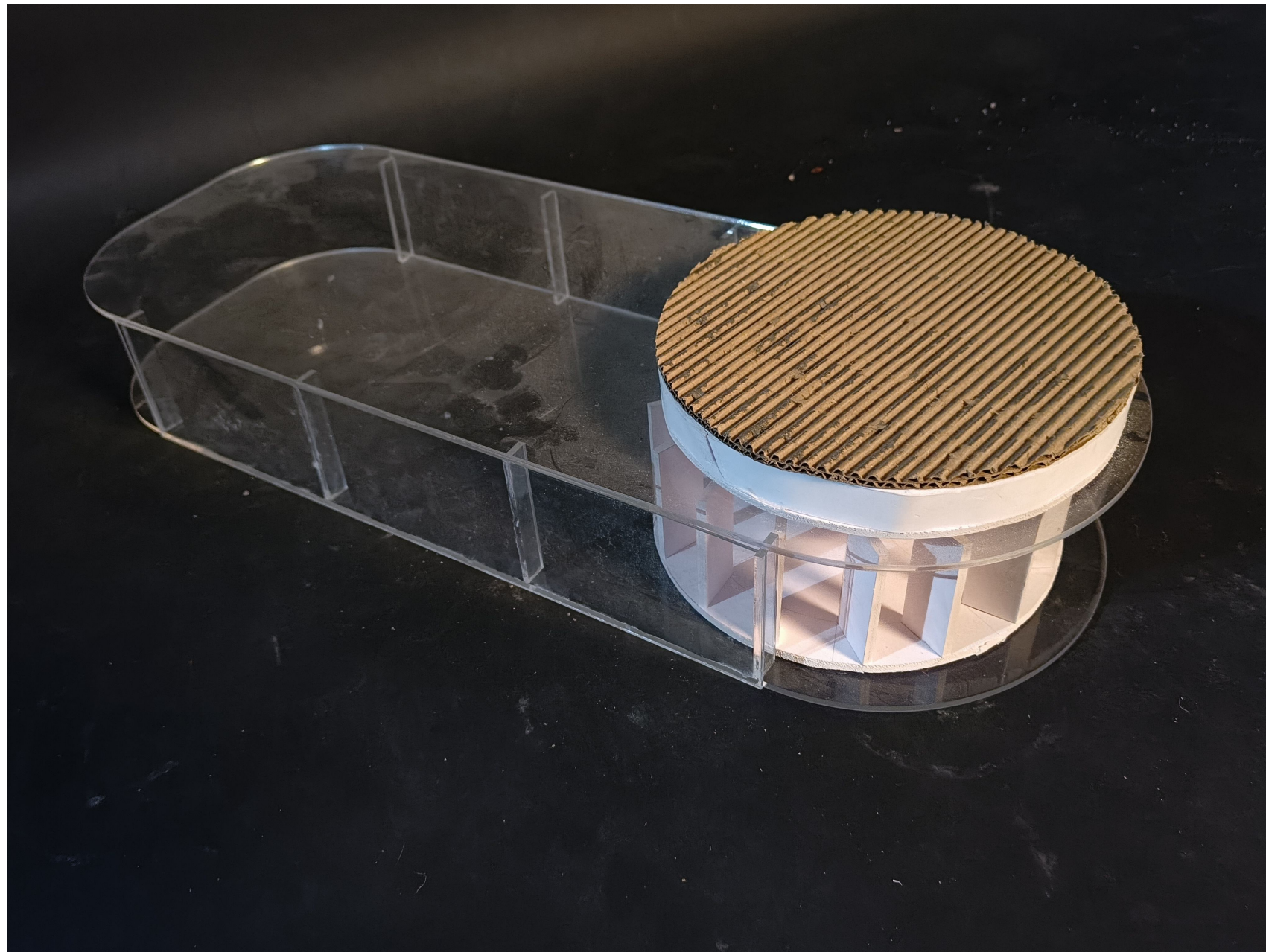
Concept 04



Inspired by shape of lungs
and a firefly which glows



Actual size mockups

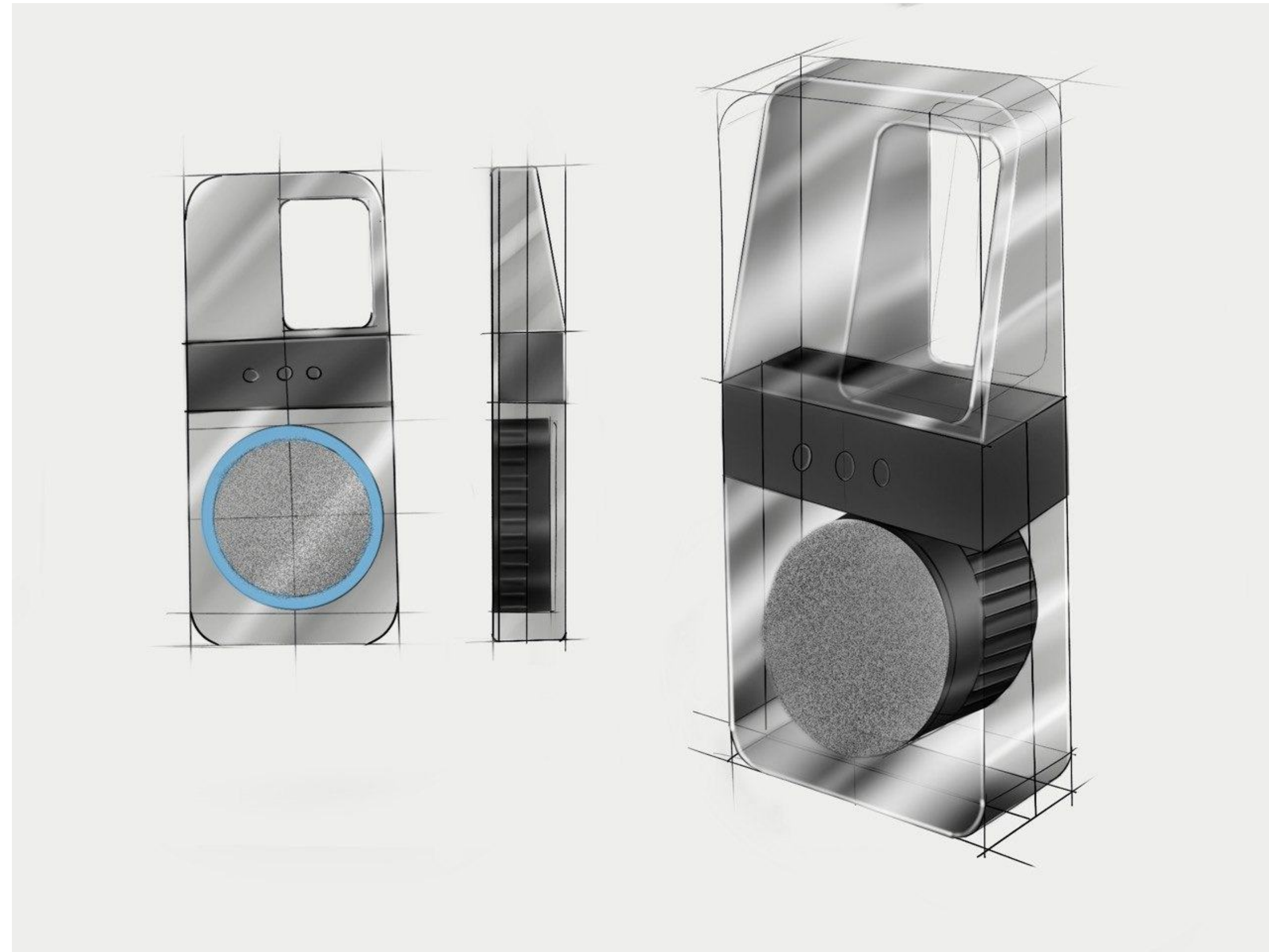
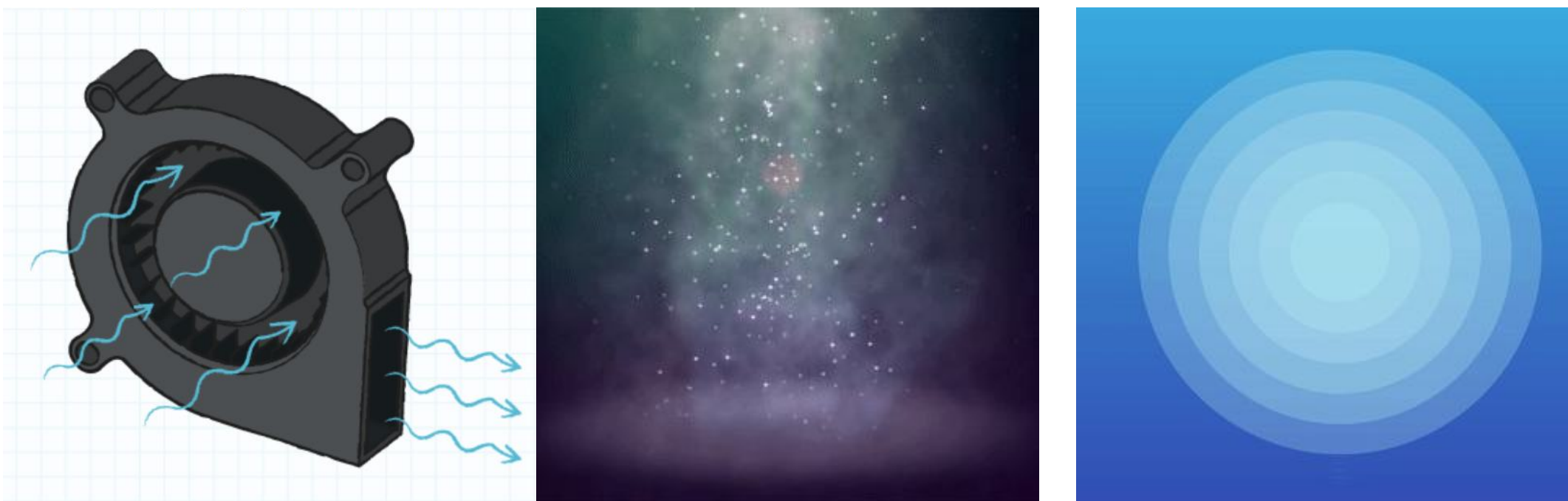


Selected Concept

Elongated shape

Placement - Wall mounted

Transparent Inlet Area

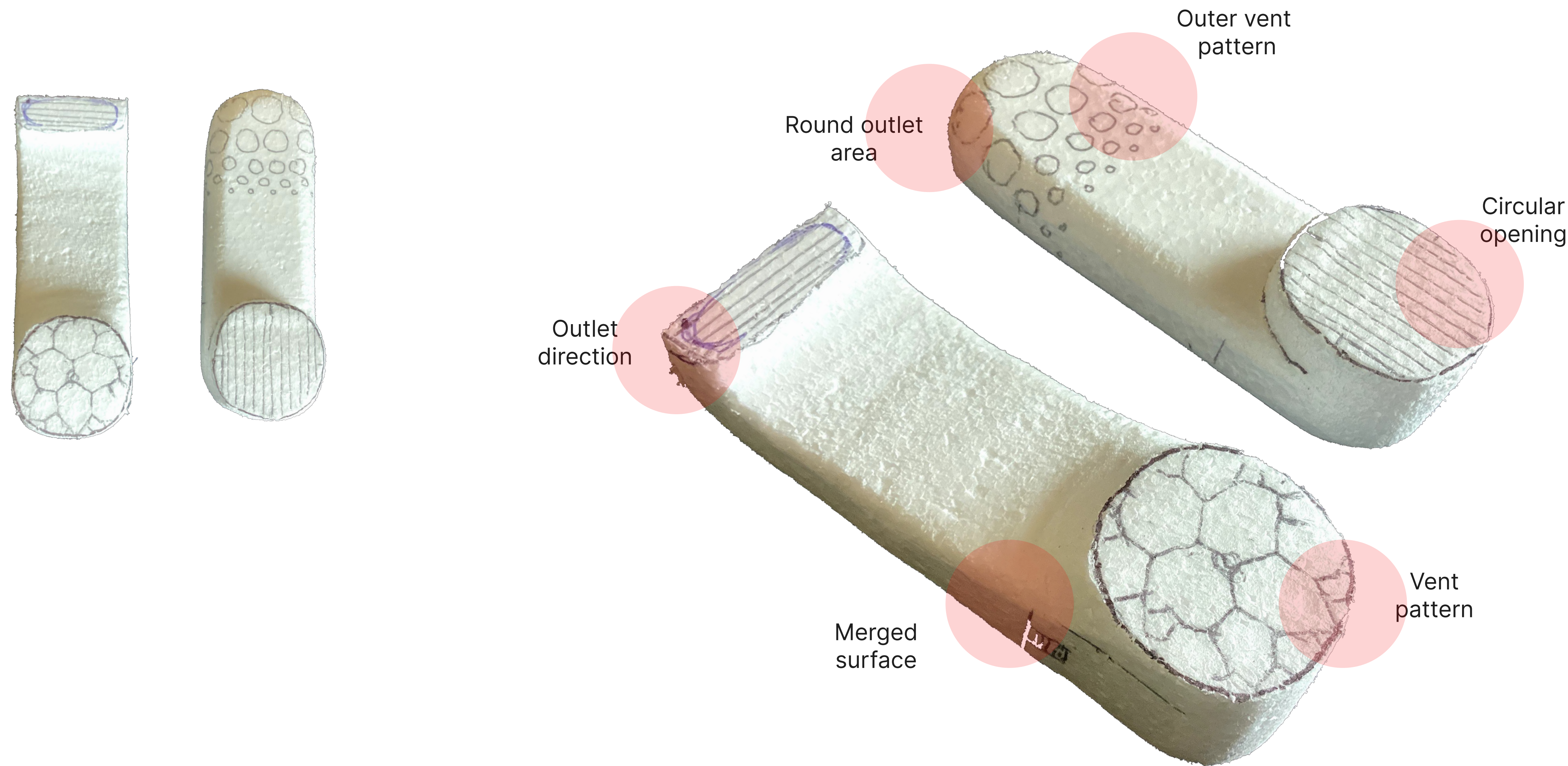


Form exploration

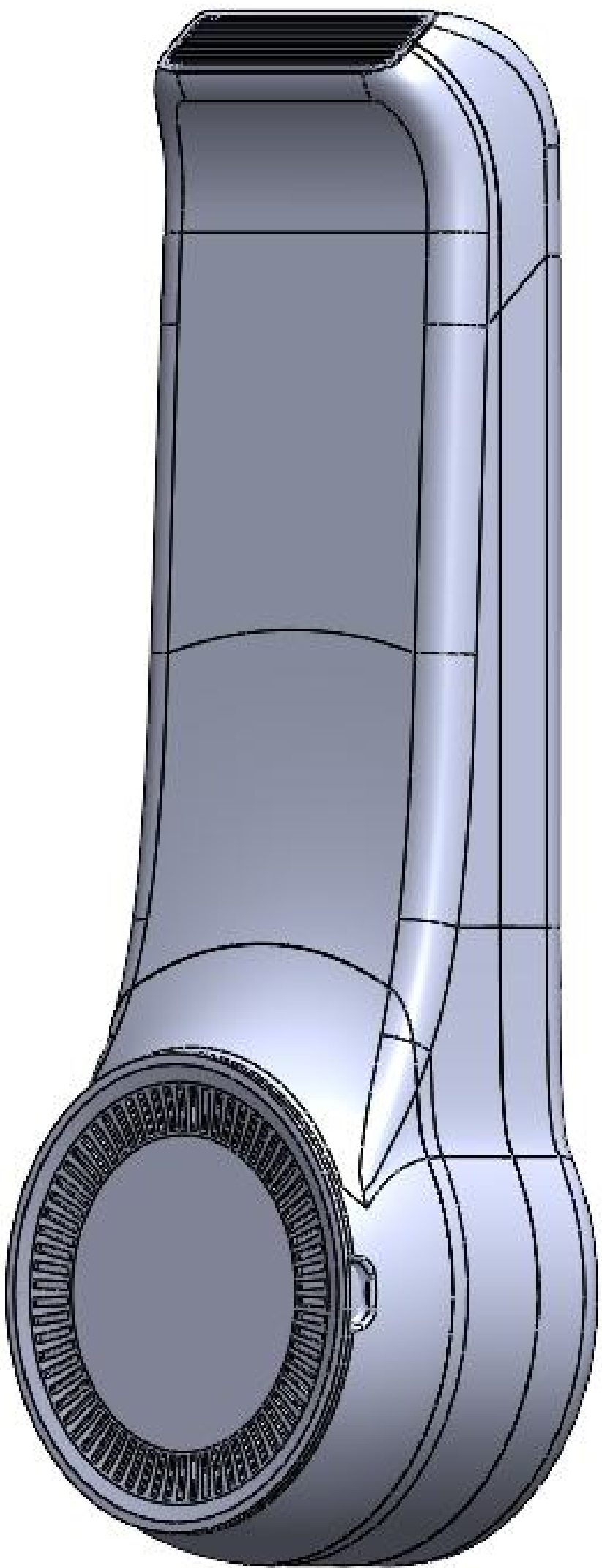
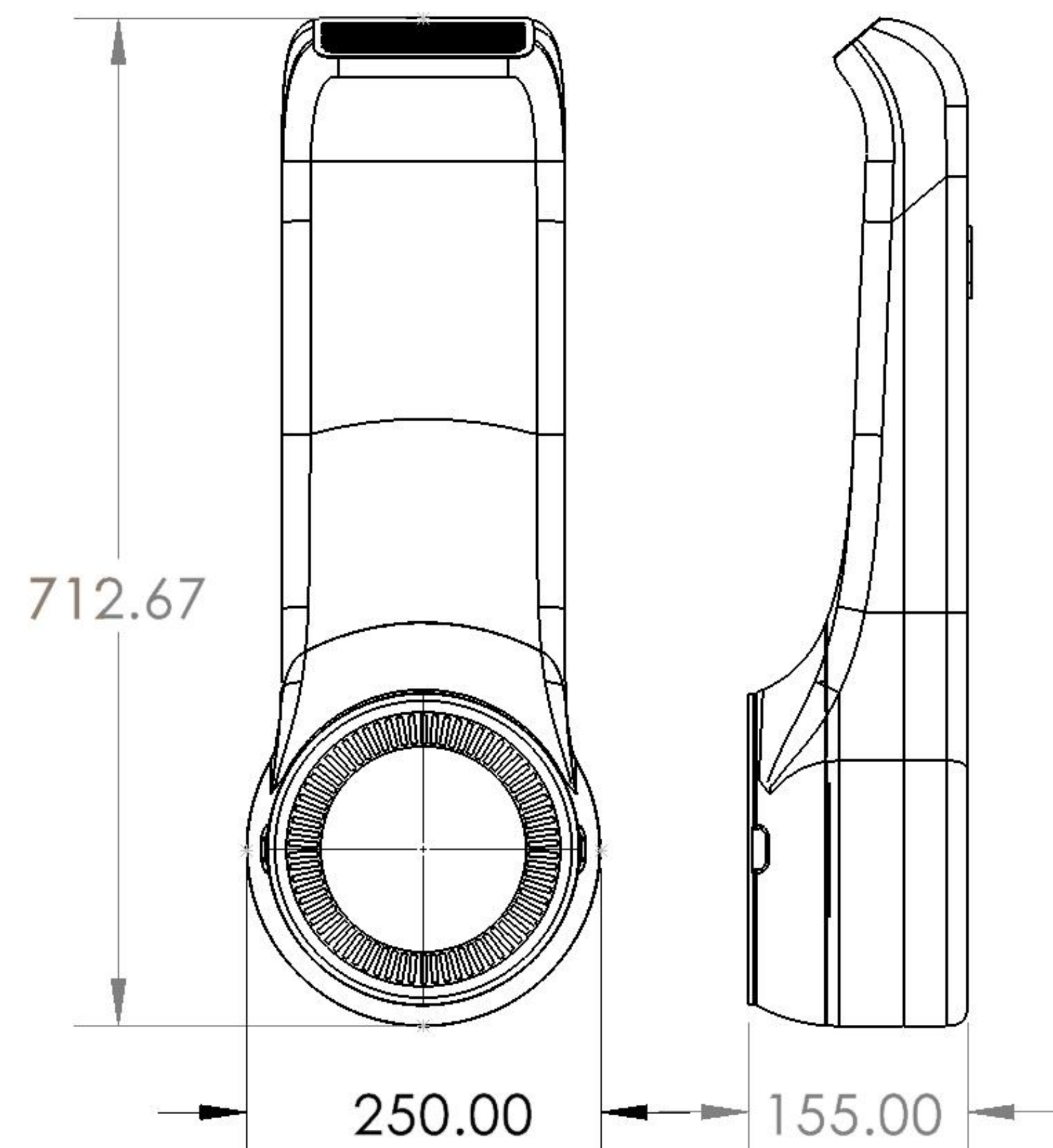
Several iterative forms were crafted in the development process to determine the optimal design for the chosen air purifier concept. These diverse models were meticulously fashioned, considering various factors to refine the product. Parameters such as functionality, aesthetics, and user-friendliness were carefully weighed in the creation of each foam prototype. The iterative method allowed for a thorough exploration of design possibilities, enabling the selection of the most efficient and visually appealing form. Through this thoughtful and systematic approach, the final air purifier design emerged as a culmination of careful considerations and continuous refinement in response to the unique challenges and requirements of the project.



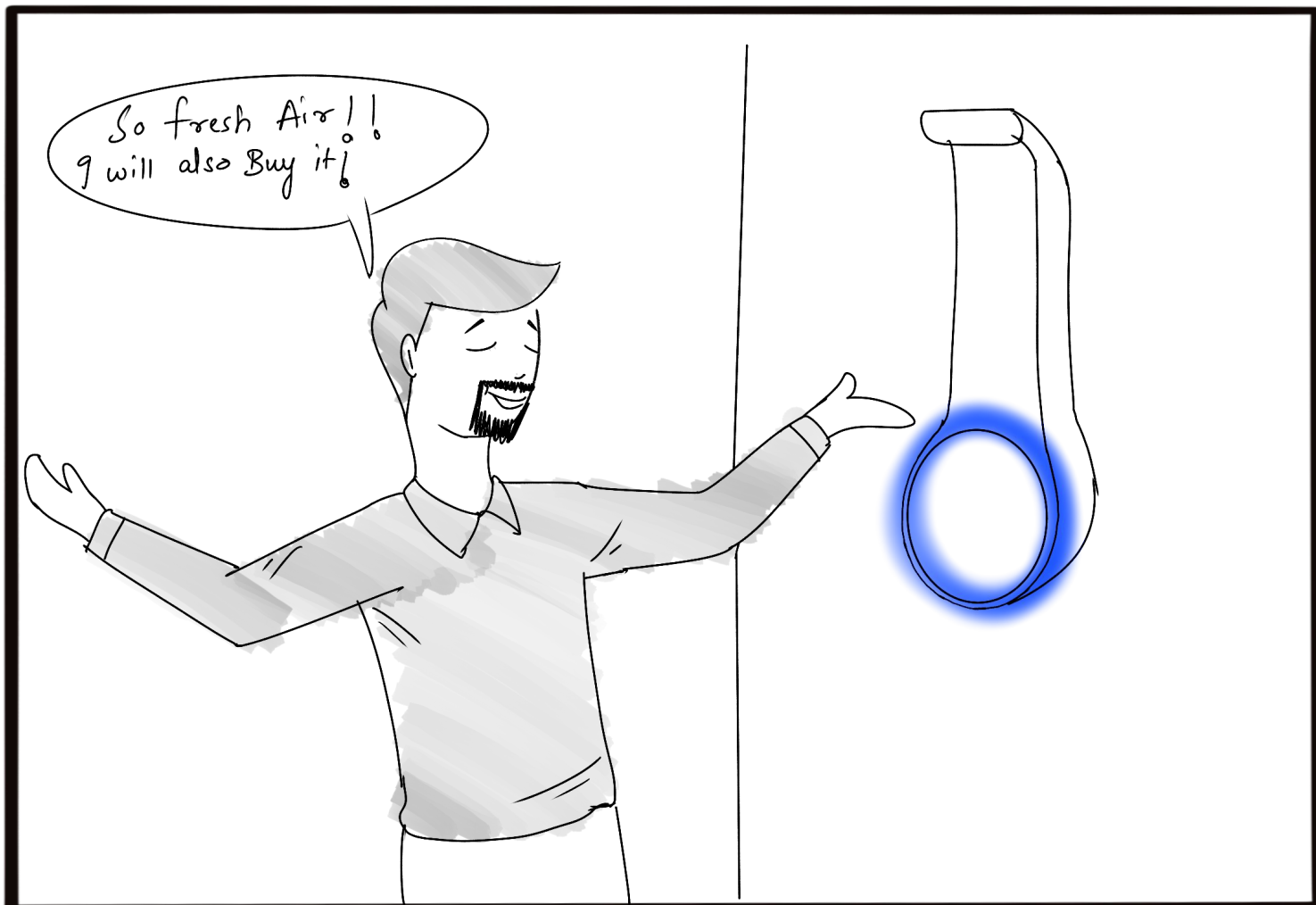
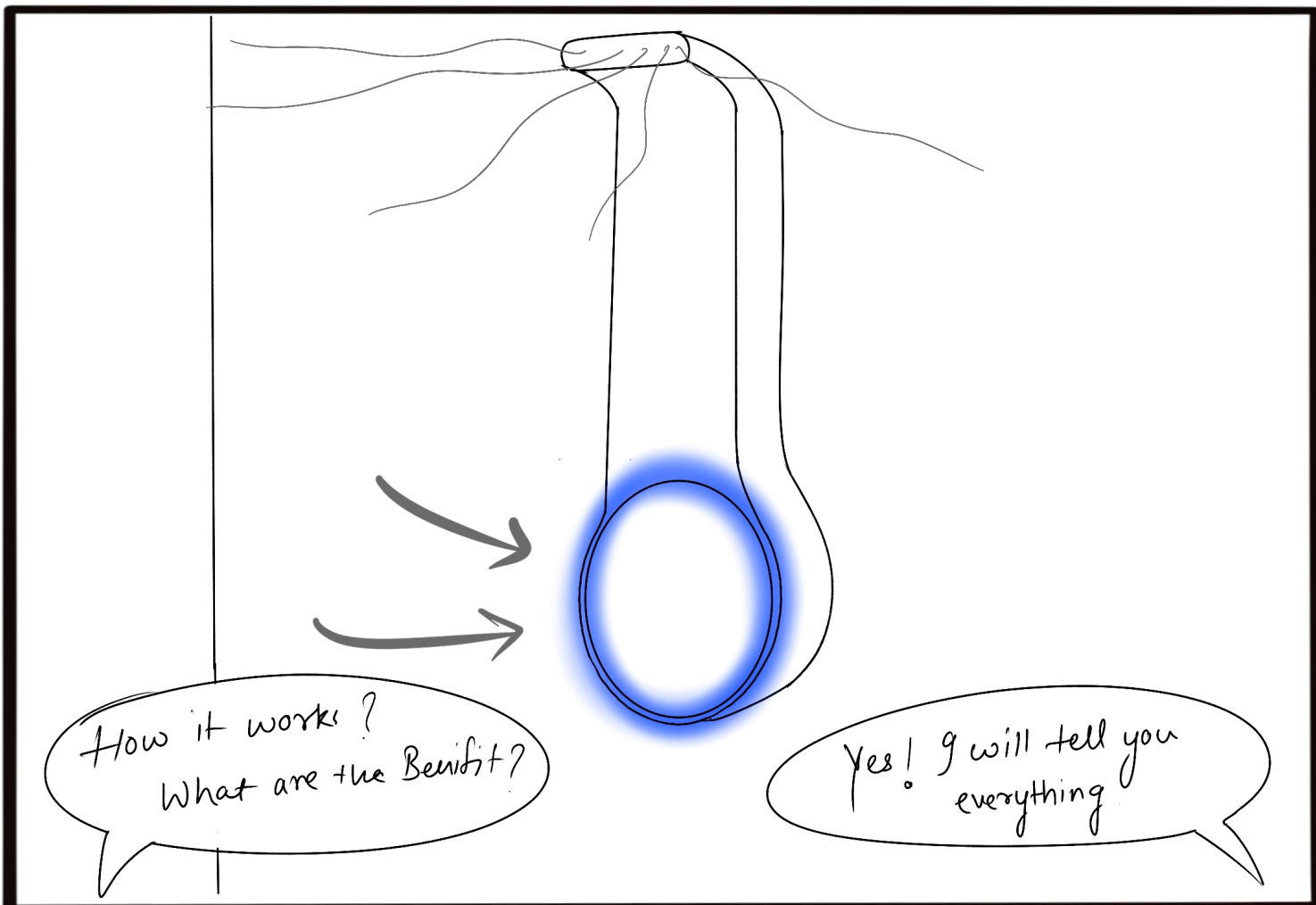
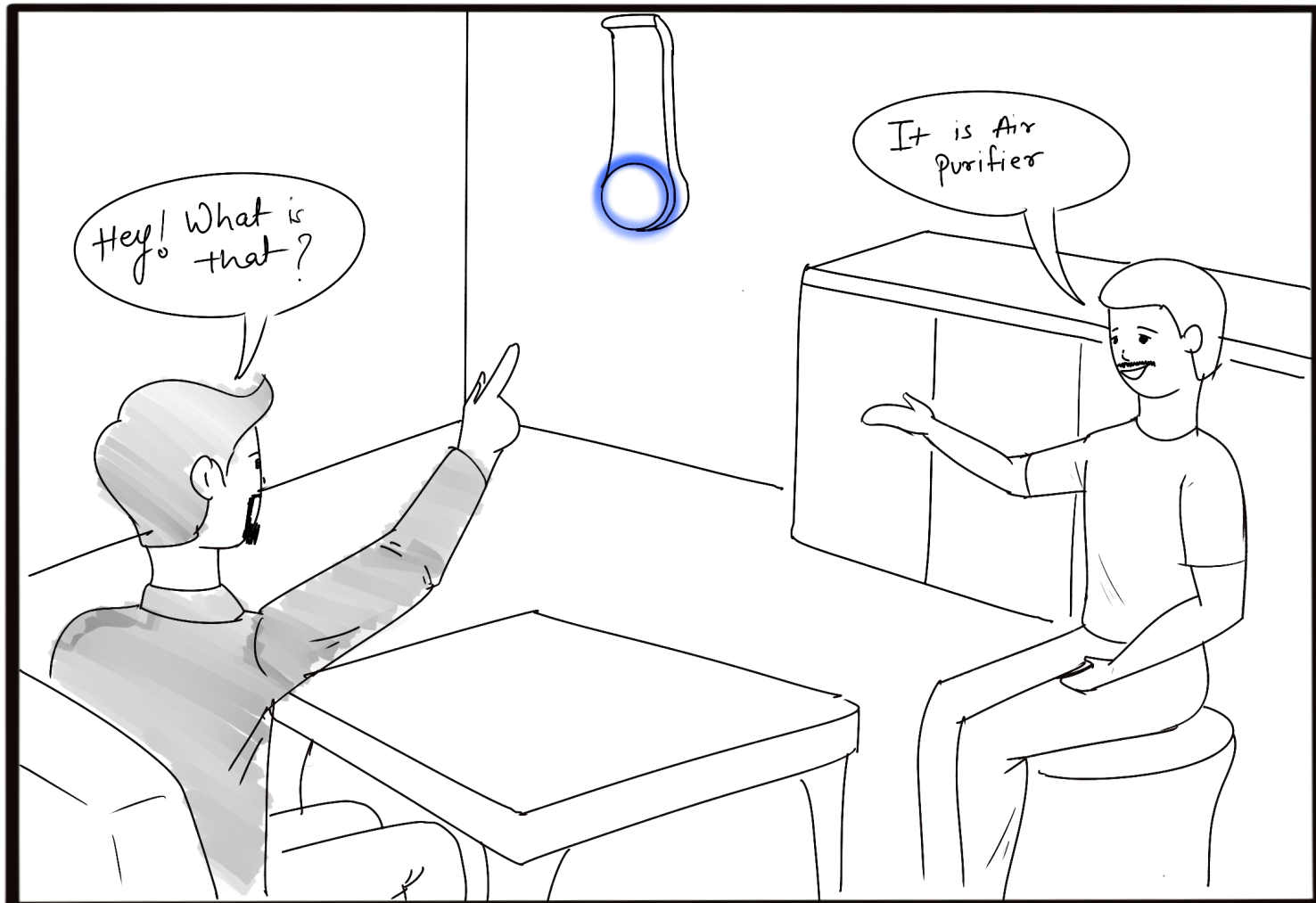
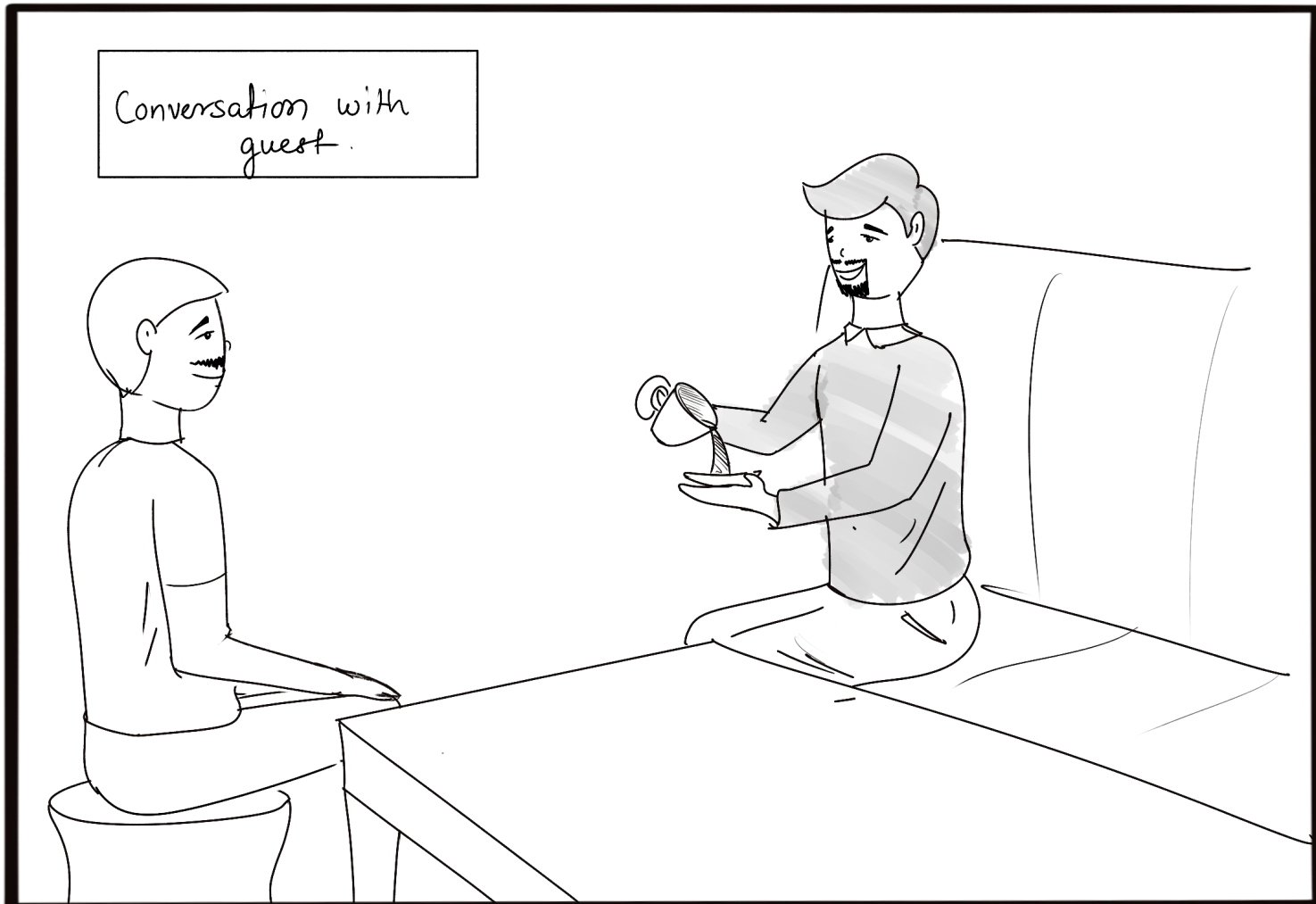
Combining Attributes



Final Design CAD



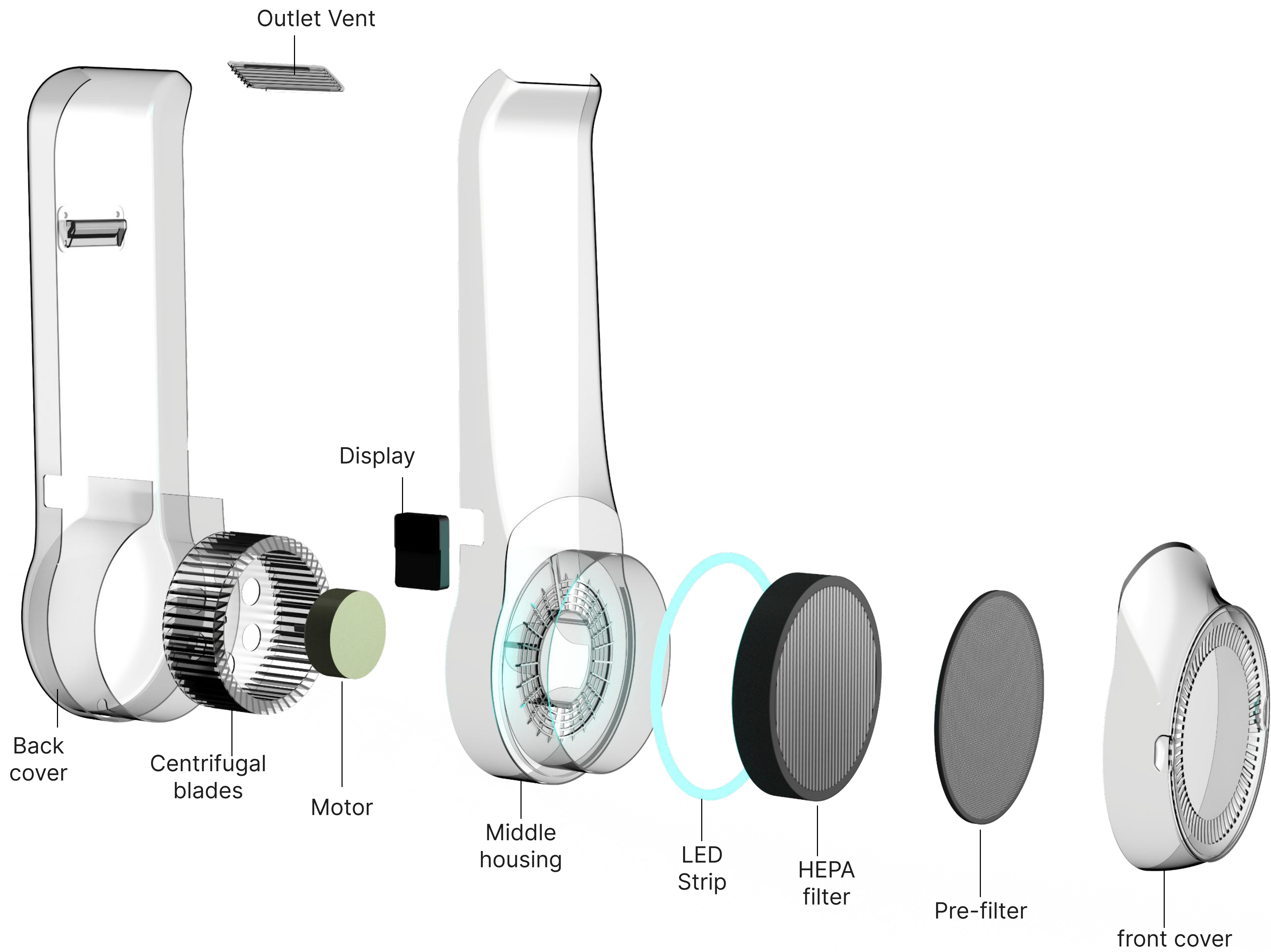
Storyboard



Final Design Render

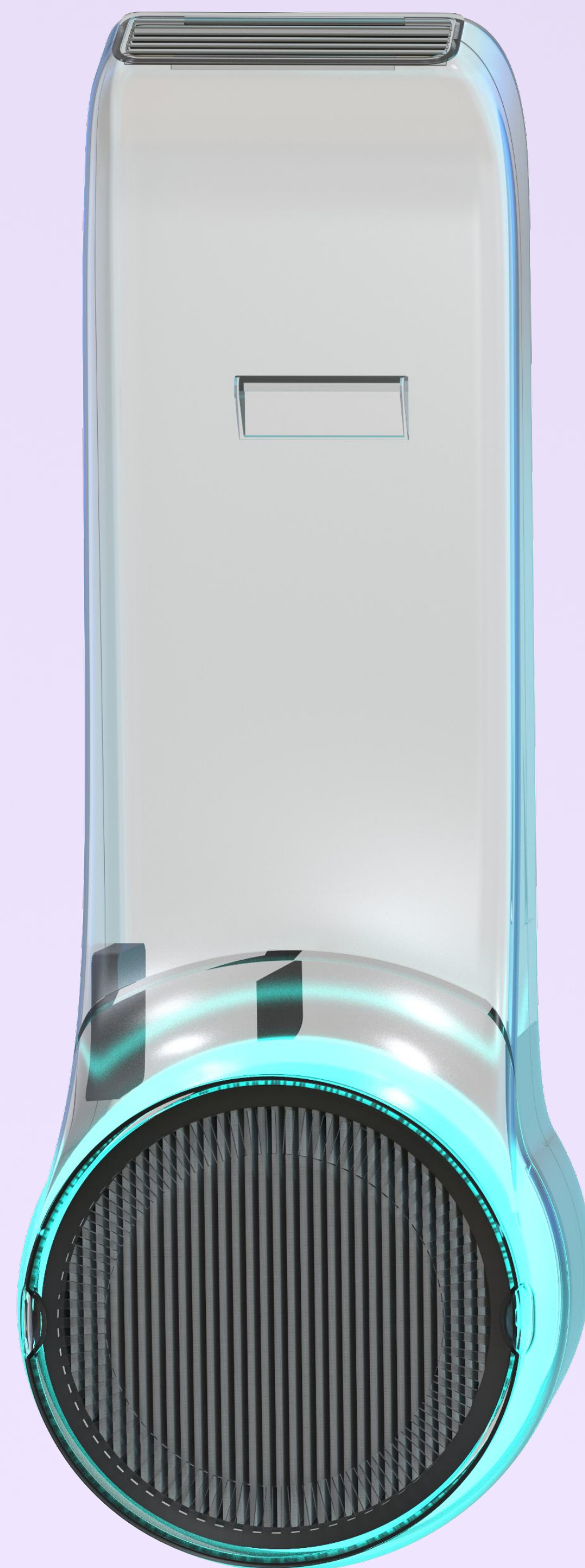
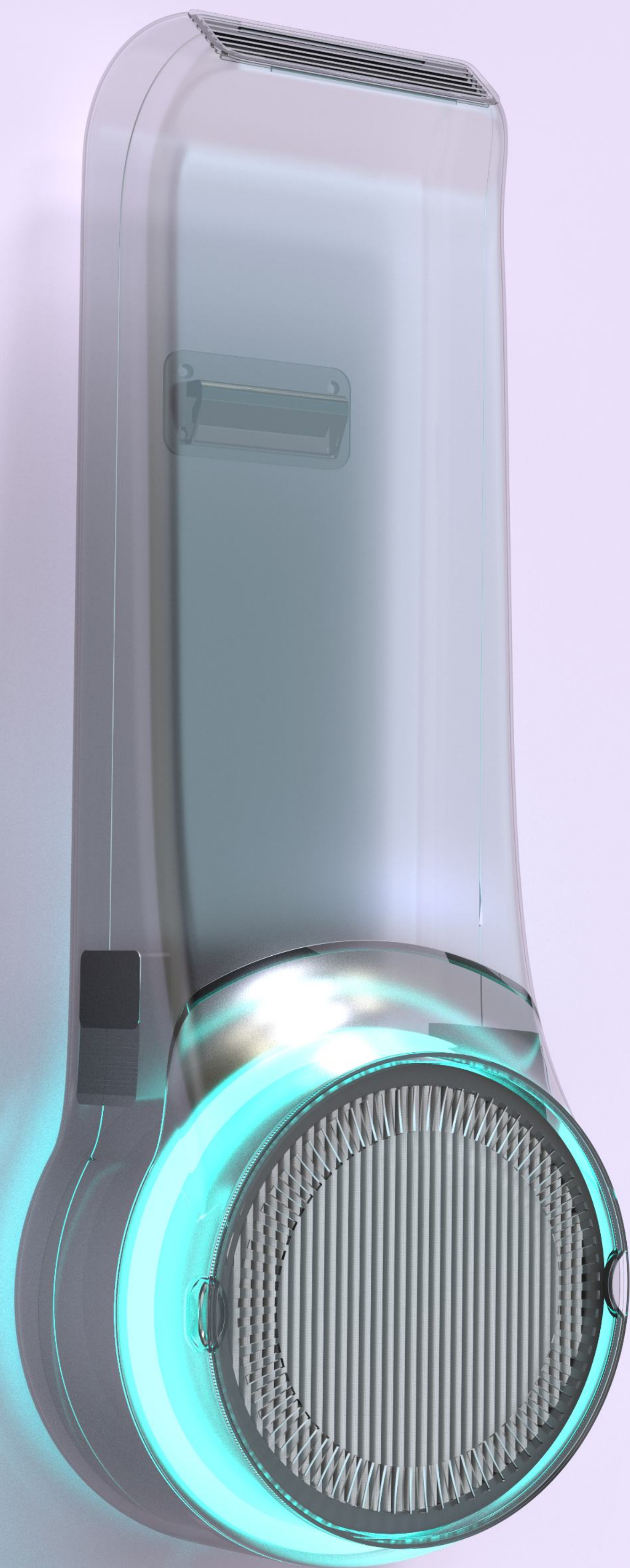


Exploded View





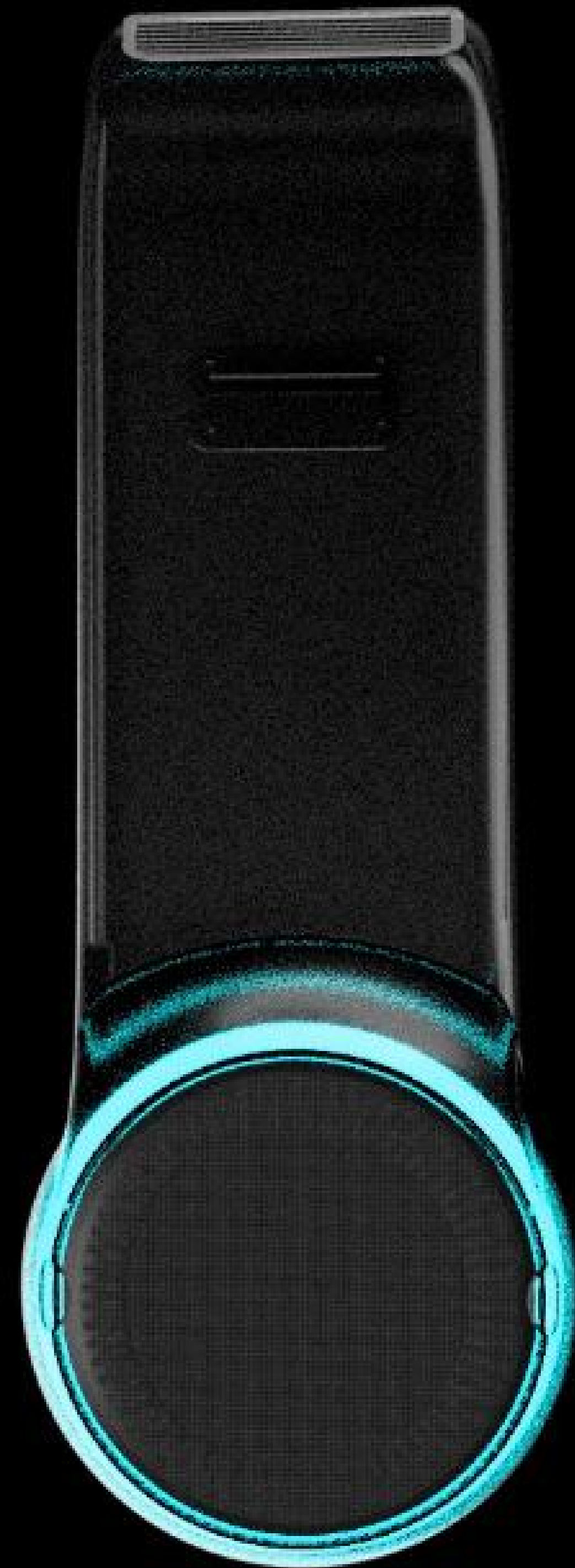




OcLEAR

Prototype Video

[https://drive.google.com/file/
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